SAFETY PRECAUTIONS

BEFORE OPERATION

Make sure handrails and walkways are free of grease and oil. Do not leave too parts or other obstructions on the walkways.

Before starting the plant, be sure personnel are clear of the moving parts.

Before starting the power unit, be sure all clutches are disengaged.

Do not smoke and make certain there are no open flames in the immediate area w ing the fuel tank. Keep the container in contact with the tank being filled, or provide to prevent a spark from igniting the fuel vapors.

DURING OPERATION

Do not wear loosely hanging clothing or neck ties on the job. Wear goggles or safe es, gloves, and hard hats during crushing operations.

Be sure all guards and covers are installed in their proper locations.

Do not operate the engine in an enclosed area unless the exhaust fumes are pipe outside. Inhalation of exhaust fumes may result in serious illness or death.

Stand clear of hauling equipment that is dumping material into the hopper.

Keep the equipment firmly blocked while operating.

Always keep hands clear of moving parts. Never attempt to wipe oil, refuel, or justments while the plant is in operation.

Report or correct any conditions that may result in injury to personnel if operat be continued.

AFTER OPERATION

Make adjustments in a proper manner. Be sure all guards and covers are properly after adjustment or maintenance operation.

Do not perform welding operation until the welder ground is placed as near to of welding as possible to prevent possible arcing through bearings or other vital par

Do not use a lifting device with a capacity of less than 12,500 pounds when lif major assemblies. Use an adequate lifting device when lifting heavy components. Do suspended major assemblies or components to swing. Failure to observe this warning sult in serious injury or death to personnel.

TECHNICAL MANUAL
No. 5-3820-233-35/1

HEADQUARTE
DEPARTMENT OF T
WASHINGTON, D. C., *25*

DIRECT SUPPORT, GENERAL SUPPORT AND
DEPOT MAINTENANCE MANUAL

CRUSHER, JAW, DIESEL ENGINE DRIVEN, SEMITRAILER MOUNTED, 35 TON PER HOUR CAPACITY (IOWA MANUFACTURING COMPANY MODEL 2A-2A) FSN 3820-851-6728, COMPONENT OF CRUSHING AND SCREENING PLANT, DIESEL ENGINE DRIVEN, FSN 3820-878-4285

CHAPTER 1

INTRODUCTION

Section I. GENERAL

1. Scope

a. These instructions are published for the use of direct and general support and depot maintenance personnel maintaining the "Iowa Manufacturing Model 2A-2A Portable Jaw Crusher." They provide information on the maintenance of the equipment, which is beyond the scope of the tools, equipment, personnel, or supplies normally available to using organizations.

b. Report of errors, omissions, and recommendations for improving this publication by the individual user is encouraged. Reports should be submitted on DA Form 2028 (Recommended Changes to DA Publications) and forwarded direct to Commanding General, U. S. Army Mobility Equipment
ATTN: AMSME-MPP, 4300 C
Boulevard, St. Louis, Mo. 63120.

c. Report all equipment improver
ommendations as prescribed by TI

2. Record and Report Forms

a. DA Form 2258 (Depreservati
of Engineer Equipment).

b. For other record and report fo
cable to direct and general support
maintenance, refer to TM 38-750.

Note. Applicable forms, excluding Sta
46 (United States Government Motor V
erator's Identification Card) which is ca
operator, shall be kept in a canvas bag mo
equipment.

Section II. DESCRIPTION AND DATA

3. Description

A general description of the Portable Jaw Crusher, the location and description of the identification and instruction plates, and information on the differences in models are contained in the Operator and Organizational Maintenance Manual. The repair and maintenance instructions are described in appropri

crushed (base
material weig
100 lbs. per cu
foot)

c. Engine.

Manufacturer	General Motors
Model	4031C
Series	71
No. of cylinders	4

d. Delivery Conveyor.

Type	Belt
Belt dimensions	Width—24 inches (4 ply) Belt length—52 feet
Length conveyor	23 feet
Bearings	
Head pulley	Flange type
Tail pulley	Pillow block type
Toughing roll assembly	Three roll type
Diameter	4 inches
Bearings	Sealed ball bearings
Retrun roll assembly	Single roll type
Diameter	4 inches
Bearings	Sealed ball bearing
Snub roll	Disc type
Diameter	6 and 8 inches
Bearings	Flange type—both snub rolls
Head pulley	12 inch dia, solid, lagged
Tail pulley	10 inch dia, wing

e. Feeder.

Type	Reciprocating plate
Inside width (feeder plate).	21-3/4 inches
Length of plate	61-3/4 inches
Stroke (adjustable)	0-6 inches
Capacity (Tons/Hv)	150
Grizzly opening	2-1/2 inches no
Clutch	Twin Disc Model CL208
Grizzly Length	18-1/4 inches

f. Crusher.

Type	Overhead eccent
Size	15 inches x 24 i
Drive	V-Belt
RPM	300
Bearings	Roller, self-alini
Pitman	One piece electr steel
Jaws	Manganese stee reversible
Key plates	Manganese stee reversible

g. Standard Engine Nut and Bo Data.

Size Nut or Bolt	Torque lb-ft	Size Nut or Bolt	Torque lb-ft	Size Nut or Bolt	Torq lb-f
1/4-20	7-9	7/16-20	57-61	3/4-10	240-
1/4-28	8-10	1/2-13	71-75	3/4-16	290-
5/16-18	13-17	1/2-20	83-93	7/8-9	410-
5/16-24	15-19	9/16-12	90-100	7/8-14	475-
3/8-16	30-35	9/16-18	107-117	1-8	580-
3/8-24	35-39	5/8-11	137-147	1-14	685-
7/16-14	46-50	5/8-18	168-178		

h. Specific Engine Nut and Bolt Torque Data.

Cylinder Block		
Hand Hole Cover	3/8-16	10-15 ft-lb
Main Bearing Bolt (Boring)	5/8-11	165-175 ft-lb
Main Bearing Bolt (Assembly)	5/8-11	180-190 ft-lb
Main Bearing Nut (Boring)	5/8-18	140-155 ft-lb
Main Bearing Nut (Assembly)	5/8-18	155-185 ft-lb
Cylinder Head Stud		75 ft-lb
Main Bearing Stud		35-75 ft-lb
Cylinder Head		

Crankshaft		
Crankshaft Front Cover	3/8–16	
Crankshaft Front Cover	3/8–24	25–30 ft-lb
Connecting Rod Nut (lubrite)	7/16–20	60–70 ft-lb
Connecting Rod Nut (Castellated)	7/16–20	65–75 ft-lb
Crankshaft Front Cover	1/2–13	80–90 ft-lb
Main Bearing Bolt	5/8–11	180–190 ft-lb
Main Bearing Nut	5/8–18	155–185 ft-lb
Crankshaft End Bolt	1–14	290–310 ft-lb
Flywheel and Flywheel Housing		
Flywheel Bolts	9/16–18	150–160 ft-lb
Oil Pan Bolts	5/16–18	10–12 ft-lb
Flywheel Housing Bolts	3/8–16	25–30 ft-lb
Idler Gear Hub and Spacer	3/8–16	40–45 ft-lb
Idler Gear Hub and Spacer	3/8–16	25–40 ft-lb
Flywheel Housing Bolts	3/8–24	25–30 ft-lb
Lifter Bracket Bolts	7/16–14	55–60 ft-lb
Flywheel Housing Bolts	1/2–13	90–100 ft-lb
Piston and Piston Rings		
Air Box Cover Bolt	3/8–16	10–15 ft-lb
Connecting Rod Nut (Lubrite)	7/16–20	60–70 ft-lb
Connecting Rod Nut (Castellated)	7/16–20	65–75 ft-lb
Camshaft and Balance Shaft		
Blower Drive Coupling to Gear Hub Bolt	5/16–24	20–25 ft-lb
Idler Gear Bearing Retainer Bolt	5/16–24	24–29 ft-lb
Flywheel Housing Bolts	3/8–16	25–30 ft-lb
Cam and Balancer Shaft End Bearing Bolt	3/8–16	35–40 ft-lb
Flywheel Housing to Idler Gear Hub and Spacer (Self Locking Bolt only)	3/8–16	40–45 ft-lb
Flywheel Housing to Idler Gear Hub and Spacer (Wired Bolt only)	3/8–16	25–30 ft-lb
Balance Weight Cover Bolt	3/8–16 and 24	25–30 ft-lb
Camshaft Intermediate Bearing Lock Screw	3/8–24	15–20 ft-lb
Balance Weight to Hub Bolt	3/8–24	25–30 ft-lb
Blower Drive Gear Hub Bearing Support Bolts & Nuts	3/8–24	25–30 ft-lb
Balance Weight to Timing Gear Bolt		
Generator Drive Bearing Retaining	3/8–24	25–30 ft-lb
Bolt	7/16–14	30–35 ft-lb
Generator Drive Oil Seal Retaining Bolt	7/16–14	30–35 ft-lb
Tachometer Drive Cover Bolt	7/16–14	30–35 ft-lb
Generator Drive Bearing Retaining Bolt	1/2–13	30–35 ft-lb
Generator Drive Oil Seal Retaining Bolt	1/2–13	30–35 ft-lb
Tachometer Drive Cover Bolt	1/2–13	30–35 ft-lb
Rocker Shaft Bolt	1/2–13	90–100 ft-lb
Idler Gear and Dummy Hub Bolt	1/2–13	80–90 ft-lb

Air Intake System		
Blower Lower Front Bearing Retaining Bolt (Allen Head)	5/16-24	1
Blower Drive Plate-to-Drive Hub Bolt	5/16-24	2
Blower Drive Hub-to-Blower Rotor Gear Bolt	5/16-24	2
Air Inlet Housing-to-Blower Housing Bolt	3/8-16	1
Blower Housing-to-Cylinder Block Bolt	7/16-14	5
Blower Rotor Timing Gear Bolt	7/16-20	5
Blower Rotor Timing Gear Bolt	1/2-20	5
Lubrication System		
Oil Pan Bolts	5/16-18	1
Oil Pump-to-Bearing Cap Bolt	3/8-24	2
Oil Pump Drive Idler Gear Nut (Marsden)	1/2-20	6
Oil Pan Drain Plug	18 m.m.	3
Power Take-Off		
Clutch Drive Shaft Nut	1 3/4-10	22
Clutch Driving Ring Bolt	1/2-13	7
Clutch Housing Bolt	7/16-14 x 1 1/4	4

Table 1. Engine Repair and Replacement Standards—Continued

Components	Manufacturer's Dimensions and Tolerances in Inches		Desired Clearance		Maximum Allowable Wear and Clearance
	Min.	Max.	Min.	Max.	
Crankshaft					
Journal Diameter—Main Bearing	3.499	3.500	------	------	------
Journal Diameter—Connecting Rod	2.749	2.750	------	------	------
Journal Out-of-Round	------	0.00025	------	------	0.0010
Journal Taper	------	0.0005	------	------	0.0015
Runout on Journals					
No. 2 and No. 4 Journals	------	0.002	------	------	------
No. 3 Journal	------	0.004	------	------	------
Thrust Washer, Tsickness	0.1205	0.1220	------	------	------
End Thrust Clearance (End Play)	------	------	0.0040	0.0110	0.0180
Main Bearings					
Bearing Inside Diameter (Vertical Axis)	3.5014	3.5034	------	------	------
Clearance—Bearing to Journal	------	------	0.0014	0.0044	0.0060
Bearing Thickness—90° From Parting Line	0.1548	0.1553	------	------	0.1530 (min.)
Connecting Rod Bearings					
Inside Diameter (Vertical Axis)	2.7514	2.7534	------	------	------
Clearance—Bearing to Crankshaft Journal	------	------	0.0014	0.0044	0.0060
Bearing Thickness—90° from Parting Line	0.1548	0.1553	------	------	0.1530 (min.)
Cylinder Block					
Main Bearing Bore—Inside Diameter (Vertical Axis)	3.812	3.8130	------	------	------
Block Bore					
Diameter	4.6265	4.6275	------	------	------
Out-of-Round	------	0.0010	------	------	0.0030
Taper	------	0.0010	------	------	0.0020
Cylinder Liner Counterbore					
Diameter	5.0460	5.0485	------	------	------
Depth	0.4785	0.4795	------	------	------
Cylinder Liners					
Outside Diameter	4.6250	4.6260	------	------	------
Inside Diameter	4.2495	4.2511	------	------	------
Clearance—Liner to Block Bore	------	------	0.0005	0.0025	0.0030
Out-of-Round—Liner Inside Diameter	------	0.0020	------	------	0.0030
Taper—Liner Inside Diameter	------	0.0010	------	------	0.0020
Depth of Liner Flange BELOW High Block	0.0465	0.0500	------	------	0.0500
Height of Liner ABOVE Low Block	0.0020	0.0060	------	------	0.0060
Variation in Height Between Adjacent Liners	------	0.0020	------	------	0.0020
Pistons and Rings					
Piston:					
Height (Centerline of Bushing to Top of Piston)	[illegible]	[illegible]			

Table 1. Engine Repair and Replacement Standards—Continued

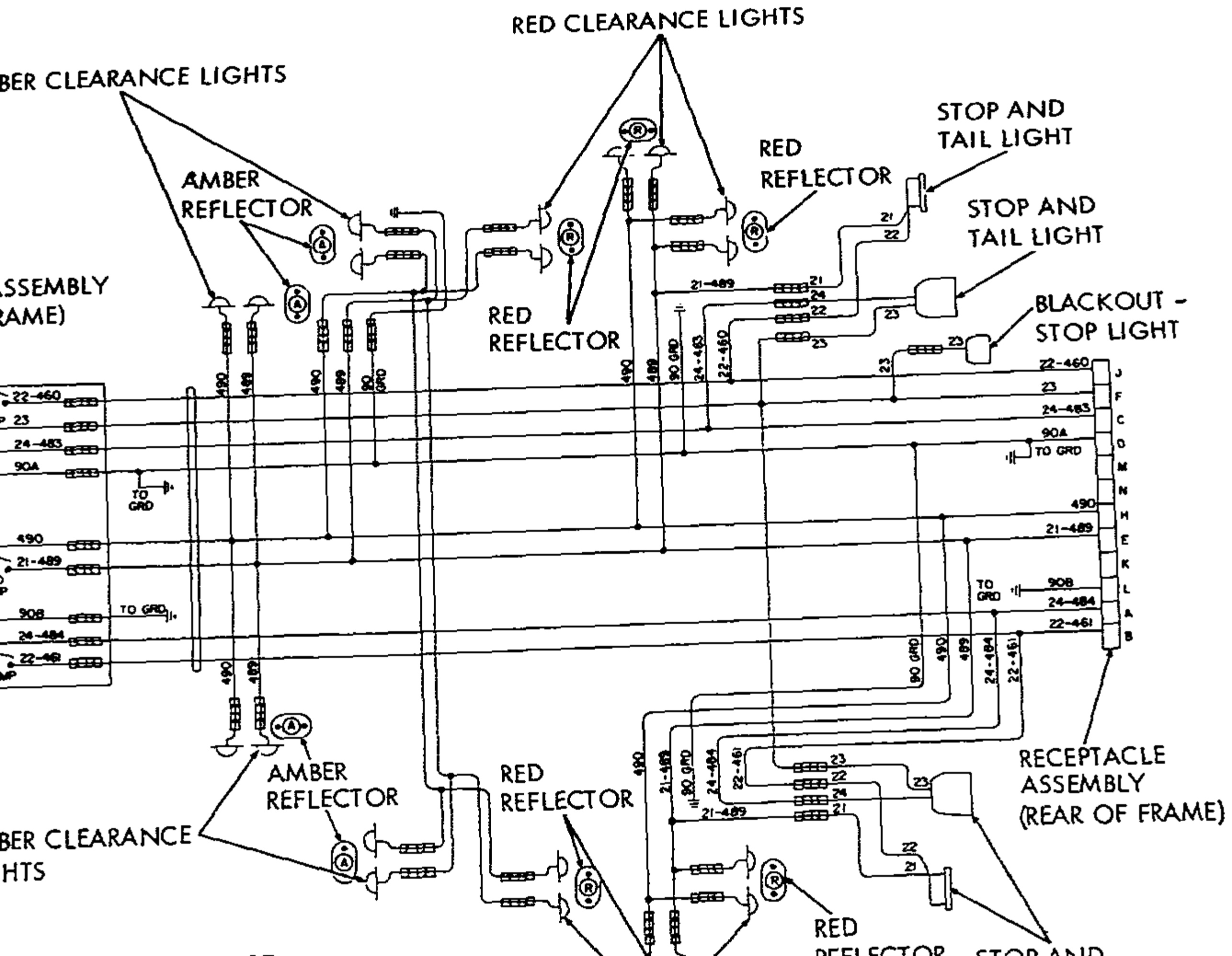
Components	Manufacturer's Dimensions and Tolerances in Inches		Desired Clearance	
	Min.	Max.	Min.	Ma
Oil Control Rings:				
Gap	0.0080	0.0230	------	----
Clearance—Ring to Groove	0.0015	0.0055	------	----
Piston Pins				
Diameter	1.4996	1.5000	------	----
Pin-to-Piston Bushing Clearance	------	------	0.0025	0.00
Pin-to-Rod Bushing Clearance	------	------	0.0015	0.00
Length	3.6050	3.6200	------	----
Pin-to-Retainer End Clearance	------	------	0.0160	0.06
Piston Pin Bushings				
Inside Diameter	1.5025	1.5030	------	----
Connecting Rod				
Inside Diameter Upper Bushing	1.5015	1.5020	------	----
Normal Rod Side Clearance	------	------	0.0060	0.01
Camshaft				
Shaft Diameter—At Bearings				
Front and Rear	1.4970	1.4975	------	----
Center and Intermediate	1.4980	1.4985	------	----
Shaft Diameter—At Gear	1.1875	1.1880	------	----
Length—Thrust Bearing End Journal	2.8740	2.8760	------	----
End Thrust	0.0040	0.0120	------	----
Thrust Washer Thickness	0.1200	0.1220	------	----
Balance Shaft				
Shaft Diameter at Bearing	1.4970	1.4975	------	----
Shaft Diameter at Gear	1.1875	1.1880	------	----
Length—Thrust Bearing	2.8740	2.8760	------	----
End Thrust	0.0040	0.0120	------	----
Thrust Washer Thickness	0.1200	0.1220	------	----
Camshaft and Balance Shaft Bearings				
Inside Diameter				
Front and Rear	1.5000	1.5010	------	----
Center and Intermediate	1.5010	1.5030	------	----
Clearance—Bearings-to-Shaft				
Front and Rear (Next to Flange)	------	------	0.0025	0.00
Center and Intermediate	------	------	0.0025	0.00
Outside Diameter of Bearings				
Front and Rear	2.1880	2.1885	------	----
Intermediate	2.1840	2.1860	------	----
Diameter of Block Bore	2.1875	2.1885	------	----
Clearance—Bearings-to-Block				
Front and Rear	------	------	0.001	0.00

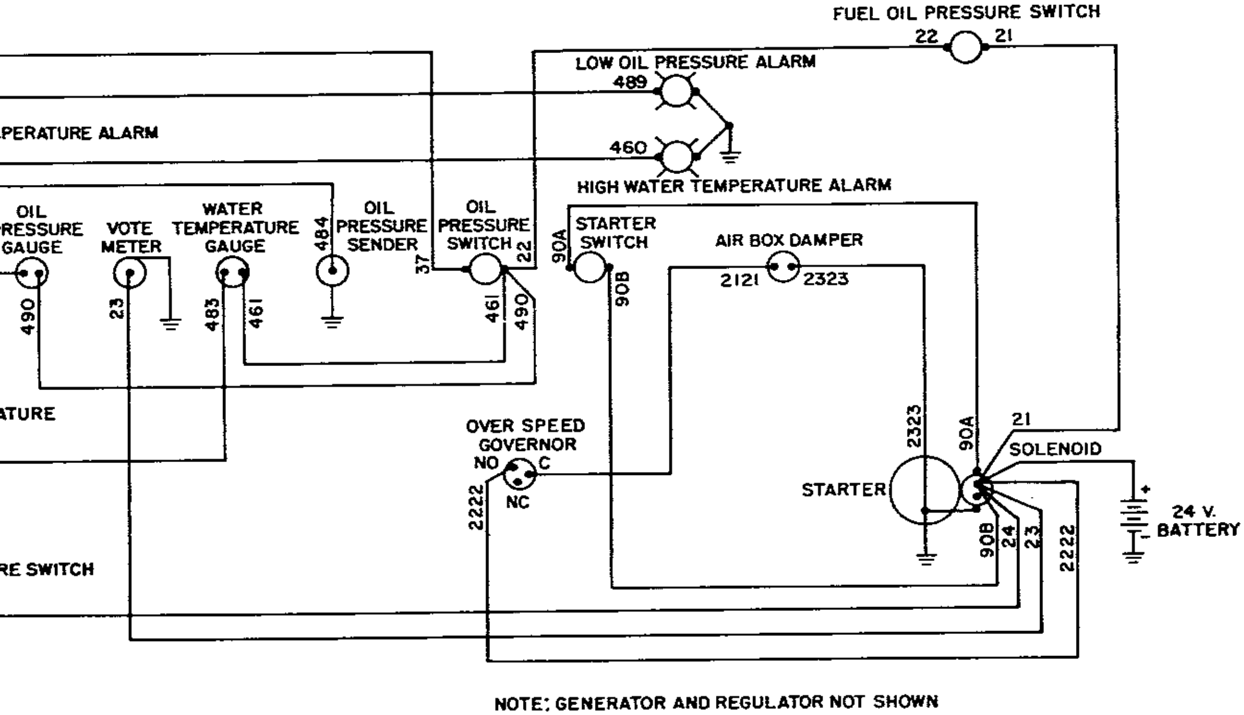
Table 1. Engine Repair and Replacement Standards—Continued

Components	Manufacturer's Dimensions and Tolerances in Inches		Desired Clearance		Maximum Allowable Wear and Clearance
	Min.	Max.	Min.	Max.	
Gear Inside Diameter	4.7490	4.7500	------	------	------
Clearance—Gear-to-Crankshaft	------	------	0.001 Press	0.001 Loose	------
Blower Drive Gear					
Backlash	0.0030	0.0080	------	------	0.010
Gear-to-Hub Fit	0.0005 Press	0.0010 Loose	------	------	------
Support-to-End Plate	0.0005 Press	0.0025 Loose	------	------	------
Support Bushing Inside Diameter	1.6260	1.6265	------	------	------
Hub Diameter—At Bushing	1.6240	1.6250	------	------	------
Hub-to-Support Bushing Clearance	------	------	0.0010	0.0025	0.0050
Hub-to-Cam Clearance	------	------	0.0020	0.0070	------
End Thrust	0.0050	0.0080	------	------	0.0100
Blower					
Backlash—Timing Gears	0.0005	0.0025	------	------	0.004
Oil Seal (Below End Plate Surface)	0.002	0.008	------	------	------
Pin-Dowel (Projection Beyond Inside Face of End Plates)	0.380	------	------	------	------
Clearances—					
Rotor to End Plate—Gear End	------	------	0.007	------	------
Rotor to End Plate—Front End	------	------	0.009	------	------
Rotor to Housing—Inlet Side	------	------	0.015	------	------
Rotor to Housing—Outlet Side	------	------	0.004	------	------
Trailing Edge of Upper Rotor to Leading Edge of Lower Rotor	------	------	0.002	0.006	0.006
Leading Edge of Upper Rotor to Trailing Edge of Lower Rotor	------	------	0.012	------	------

Table 2. Primary Jaw Crusher Plant Repair Replacement Standards

Components	Manufacturer's Dimensions and Tolerances in Inches		Desired Clearance		Maximum Allowable Wear and Clearance
	Min.	Max.	Min.	Max.	
Jaw Crusher					
Clearance—Pitman Bearing (Outer Race to Roller)	------	------	0.0025	0.006	------
Clearance—Pitman Bearing Seal	------	------	0.010	------	------
Mounted Clearance—Side Bearing (Outer Race to Roller)	------	------	0.003	0.005	------


RED CLEARANCE LIGHTS
BER CLEARANCE LIGHTS
AMBER REFLECTOR
RED REFLECTOR
STOP AND TAIL LIGHT
STOP AND TAIL LIGHT
BLACKOUT - STOP LIGHT
RED REFLECTOR
ASSEMBLY
RAME)
RECEPTACLE ASSEMBLY (REAR OF FRAME)
AMBER REFLECTOR
RED REFLECTOR
BER CLEARANCE
HTS
RED REFLECTOR
22-460
23
24-483
90A
TO GRD
490
21-489
908
24-484
22-461
90 GRD
489
21
22
24



B – POWER UNIT SCHEMATIC WIRING DIAGRAM.

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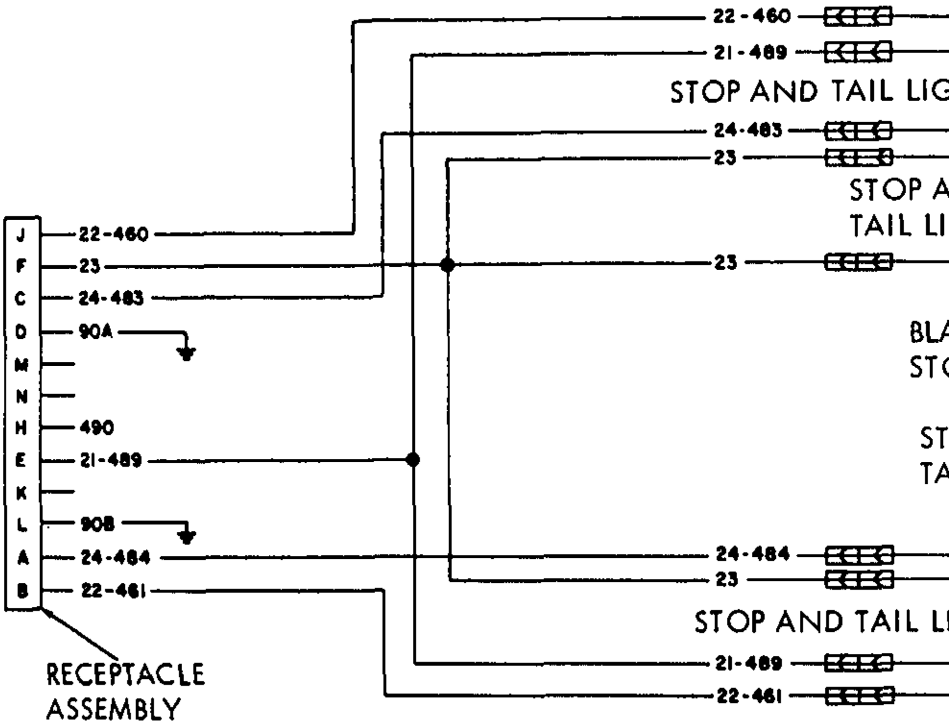
Figure 1 (2). Continued.



C - FRONT DOLLY SCHEMATIC WIRING DIAGRAM

ME 3820-

Figure 1 (3). Continued.

CHAPTER 2

GENERAL MAINTENANCE INSTRUCTIONS

Section I. SPECIAL TOOLS AND EQUIPMENT

5. Special Tools and Equipment

The special tools required to perform direct and general support and depot maintenance on the Portable Jaw Crusher are listed in Table 3 and the applicable appendix of this manual. References and illustrations indicating the use of these tools are listed in the table. No special equipment is required by direct and general support and depot maintenance personnel for performing maintenance on the Portable Jaw Crusher.

Table 3. Special Tools

Item	Part No.		Ref. Fig.	Ref. Para	Use
Wrench	(31245)	45500–751–09	32–11	59	Side bearing removal and installation
Removal nut	(31245)	697BA	32–11	59	Side bearing removal
Tightening nut	(31245)	697–01	32–26	59	Side bearing installation
Wrench	(31245)	45500–752–20	32–10	59	Sleeve lock nut removal and installation
Wrench	(31245)	45500–752–23	32–9	59	Side bearing lock nut removal and installation

6. Direct and General Support and Depot Maintenance Repair Parts

Direct and General Support and Depot Maintenance Repair Parts are listed and illustrated in TM 5–3820–235–35P.

7. Specially Designed Tools and Equipment

No specially designed tools and equipment are required.

Probable Cause	Possible Remedy
	Replace valve seats (para 42)
	Replace injector tubes (para 42)

10. Engine Lacks Power

Probable Cause	Possible Remedy
Piston assemblies worn	Replace piston assemblies (para 45)
High engine temperature caused by defective water pump	Repair defective water pump (para 33)
Improper gear train timing	Time gear train (para 50)

11. Engine will not Turn

Probable Cause	Possible Remedy
Engine is locked or seized	Disassemble engine to determine the cause and replace necessary parts

12. Low Cranking Speed

Probable Cause	Possible Remedy
Starter brush springs weak	Check brush spring tension, replace springs if necessary (para 29)
Starter commutator dirty or worn	Polish commutator, machine commutator and under-cut mica if necessary (para 29)
Starter armature burned out	Replace armature (para 29)

13. Engine Hard to Start

Probable Cause	Possible Remedy
Exhaust valves ticking or burned	Check for bent valve guide and replace if necessary (para 42)
	Check for defective valve spring and replace if necessary (para 42)
	Clean and reface valve (para 42)
Compression rings worn or broken	Replace rings (para 45)
Cylinder head gasket	Replace gasket (para 42)

Probable Cause	Possible Reme
Insufficient fuel	Clean injector sp orifices (para
	Replace injector tips (para 40)
	Replace injector and bushing a (para 40)
	Time injector ra gear (Operato Manual)
Worn fuel pump gears or pump housing	Replace gear an assembly in pu body (para 35
Fuel pump not rotating	Check blower dr if broken, repl necessary part (para 36)
	Check fuel pump gear and shaf broken, replac necessary par (para 35)
	Replace fuel pu (Operator's M

14. Low Oil Pressure

Probable Cause	Possible Rem
Poor circulation	Remove and clea cooler core (O Manual)
	Replace oil coole pass valve (Operator's M
	Replace oil pres regulator valv (Operator's M
	Check if gallery shaft or cams plugs are mis replace if par missing.
Faulty oil pump	Replace oil pum (para 44)
Dirty oil pump inlet screen	Clean screen (p

15. Engine Overheats

16. Power-Take off Clutch Slips

Probable Cause	Possible Remedy
Worn clutch facing	Replace clutch facing (para 46)
Clutch adjustment necessary	Adjust clutch refer to Operator's Manual

17. Feeder Clutch Slips

Probable Cause	Possible Remedy
Worn driving plates friction surfaces	Adjust clutch (Operator's Manual)
	Replace driving plates

18. Side and Pitman Bearings Overheat

Probable Cause	Possible Remedy
Excessive or insufficient lubricant	Refer to the Operator's Manual
Plant out of level	Level plant (Operator's Manual)
Worn toggle plate	Replace toggle plate (para 60)
Flywheels loose	Tighten flywheel against the seal
Bearing failure	Replace bearings (para 59)
Insufficient radial clearance between side bearing end cap and seal	Place wedge between pitman and bearing housing and drive at base of side bearing housing until a 0.010 inch seal clearance is obtained. Tighten the housing to base capscrews (para 59)

19. Excessive Jaw Wear

Probable Cause	Possible Remedy
Stationary jaw loose	Tighten jaw (para 59)
Incorrect crusher discharge opening	Adjust crusher discharge opening (Operator's Manual)

20. Feeder Spillage

Probable Cause	Possible Remedy
Worn wear strips	Adjust feeder (Operator's Manual)

21. Conveyor Belt Running off Center

Probable Cause	Possible Remedy
Troughing roll assembly not positioned correctly in frame	Move one end of troughing roll assembly to change belt travel to center on troughing roll assembly. Refer to Operator's Manual
Spillage of material	Adjust flashing to eliminate spillage
Plant operating in unlevel position	Level complete plant
Troughing and return roller not rotating	Free rolls or replace defective rolls if necessary
Head or tail pulley moved	Center pulley and securely lock into position with the taper lock bushings

22. Conveyor Belt Slipping

Probable Cause	Possible Remedy
Insufficient conveyor belt tension	Tighten conveyor belt. Refer to Operator's Manual
Drive pulley lagging worn	Replace lagging. Refer to Operator's Manual
Troughing or return roll assemblies not rotating freely	Free roll assemblies or replace if necessary.
Insufficient V-belt drive tension	Check drive and tighten V-belts if necessary

Section III. REMOVAL AND INSTALLATION OF MAJOR COMPONENTS

i. Remove conveyor skirtboard and fold conveyor.

24. Power Unit

a. Removal

(1) Disconnect fuel lines from the power unit (Operator's Manual).

(2) Disconnect the battery cables.

(3) Refer to figure 2 and remove the power unit.

b. Installation

(1) Refer to figure 2 and install the power unit.

(2) Install the V-belts and adjust for proper belt tension (Operator's Manual).

Note. When making the belt tension adjustment be sure the power unit clutch drive shaft is parallel with the jaw crusher eccentric shaft.

(3) Connect battery cables.

Note. Connect negative (–) battery cable last.

(4) Connect fuel lines (Operator's Manual).

(5) Connect clutch control universal joint (fig. 2).

25. Reciprocating Feeder

a. Removal

(1) Remove countershaft drive rear guard (Operator's Manual).

(2) Remove feeder drive belts (Operator's Manual).

(3) Refer to figure 3 and remove the feeder and hopper complete with feeder drive.

b. Installation.

(1) Refer to figure 3 and install the feeder and hopper complete with feeder drive.

(2) Install feeder drive belts and adjust for proper belt tension (Operator's Manual).

(3) Install countershaft drive rear guard

(4) Remove inner belt
wheel guards (Operator's Ma

(5) Remove the crush
and crusher-to-feeder counter
(operator's Manual).

(6) Remove crusher hop
platform (Operator's Manua

(7) Refer to figure 4 an
crusher.

b. Installation

(1) Refer to figure 4 an
crusher.

(2) Install crusher hop
platform (Operator's Manua

(3) Install crusher-to-p
crusher-to-feeder countershaf
just for proper belt tension
ual).

(4) Install inner belt
wheel guards (Operator's M

(5) Install the crusher g
erator's Manual).

(6) Install the front ar
shaft drive guards (Operator

(7) Install feeder clutc
ator's Manual).

27. Delivery Conveyor

a. Removal

(1) Remove the front
hand guard frame (Operator

(2) Remove the front c
hand guard (Operator's Ma

(3) Remove conveyor
Manual).

(4) Refer to figure 5
speed reducer and conveyor h

(5) Disconnect conveyor
the conveyor center support

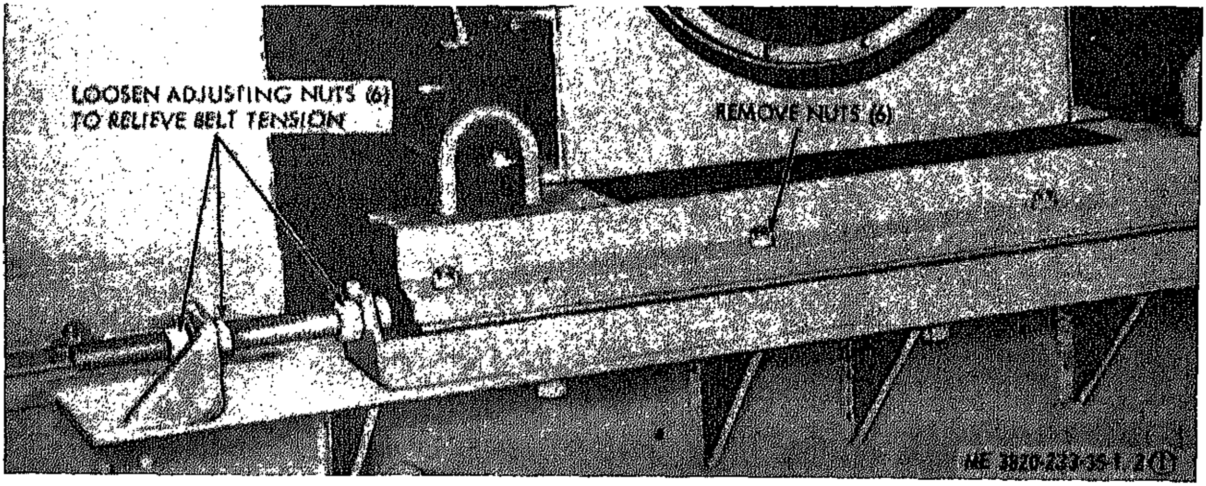
(3) Secure tail frame to conveyor center support shown on figure 2.

(4) Refer to figure 5 and install conveyor head frame and speed reducer.

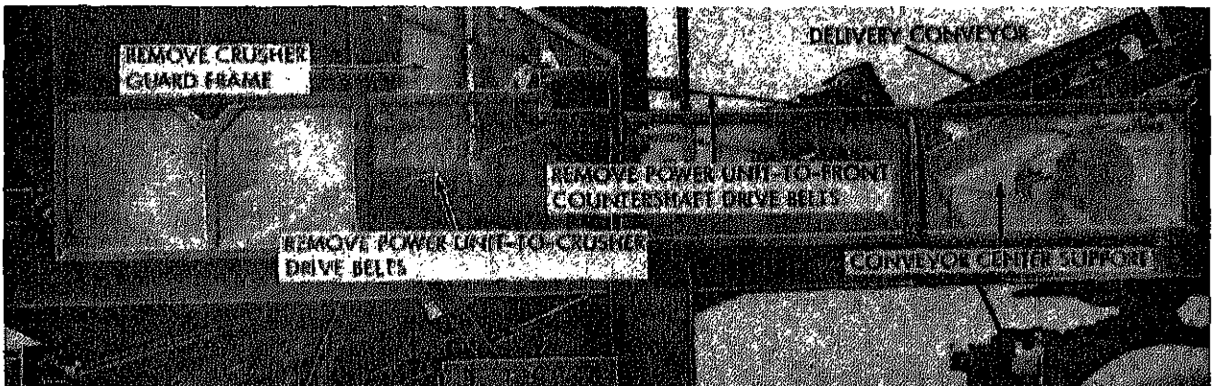
(5) Install conveyor belt (Operator's Manual).

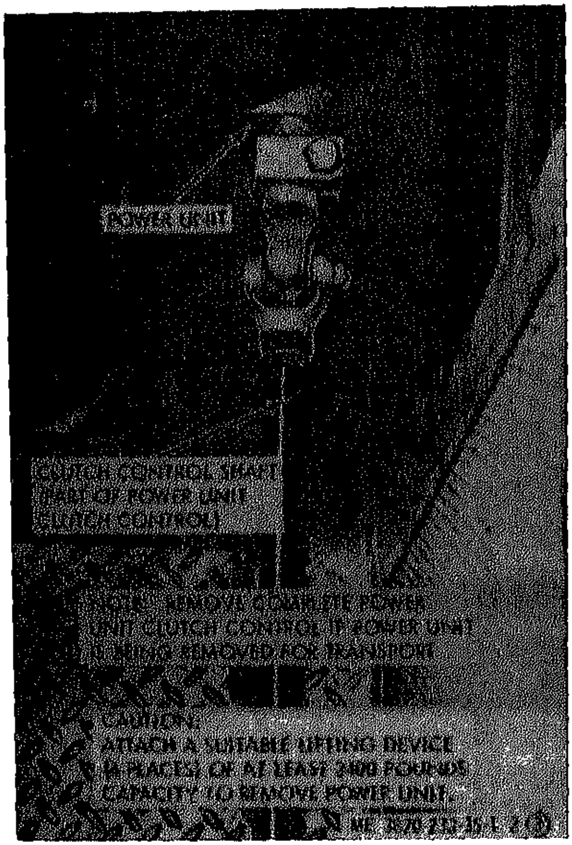
(6) Adjust for proper V-belt and conveyor belt tension (Operator's Manual).

(7) Install front countershaft right and left hand guard frame (Operator's Manual)



STEP 1. DISCONNECT POWER UNIT FROM FRAME.
Figure 2 (1). Power unit, removal and installation.



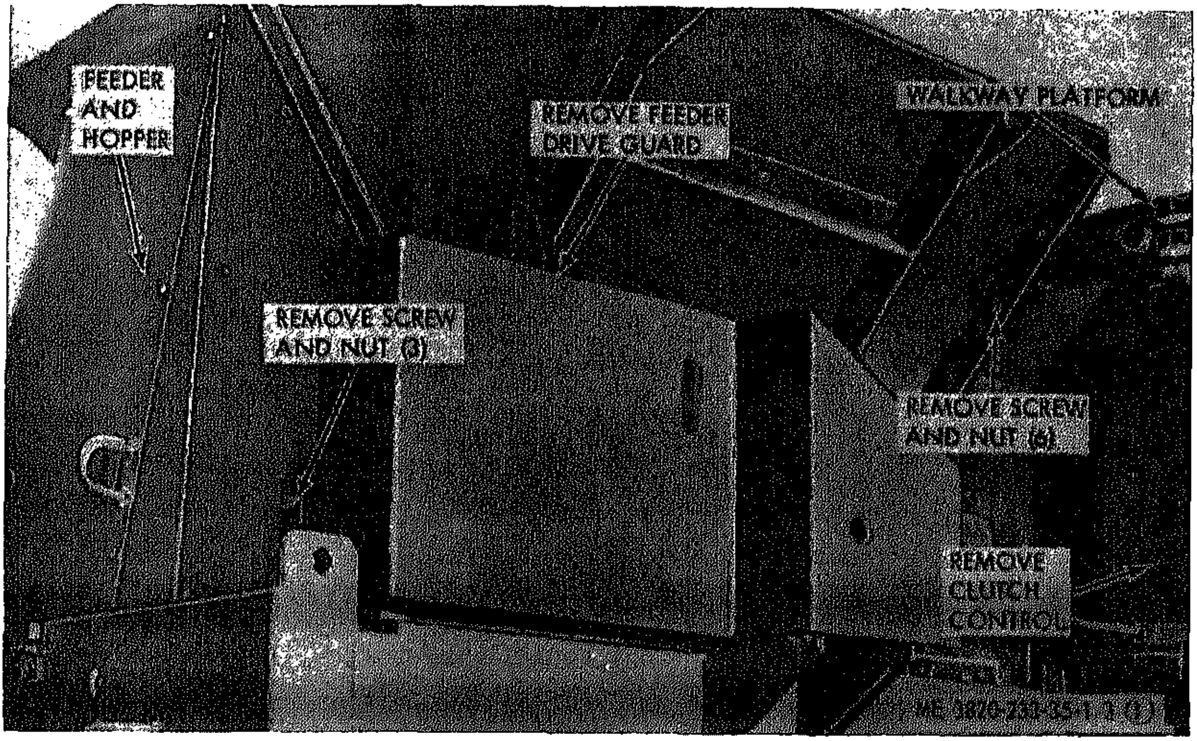


CAUTION. ATTACH A SUITABLE LIFTING DEVICE (4 PLACES) OF AT LEAST 3400 POUNDS CAPACITY TO REMOVE POWER UNIT.

STEP 3. DISCONNECT CLUTCH CONTROL SHAFT.

STEP 4. REMOVE POWER UNIT

Figure 2 (3). Continued.



STEP 1. DISCONNECT FEEDER DRIVE GUARD AND WALKWAY PLATFORM FROM FEEDER AND HOPPER.

Figure 3 (1). Feeder and feeder hopper, removal and installation.

ity, allowing them to work in essentially any type of application. But this increased capability also adds a degree of complexity to the conversion process if programmers attempt to take full advantage of Ada's power when rewriting or converting a system.

Classifying conversions by the differences between initial and final computer environments indicates the level of difficulty which should be anticipated in different types of conversions. (See the figure, adapted from John R. Wolberg, *Conversion of Computer Software* (Englewood Cliffs, NJ: Prentice-Hall, 1983), p. 20.) Within a given environment, the computer hardware can change or remain the same, as can the language. Different operating systems, requiring different versions of a language, can further complicate the conversion effort. The difficulty ratings assigned to different kinds of conversions reflect the relative impact of changes in the computer environment on the existing software.

Converting existing software into Ada involves a change of language between initial and final environments, a class 3 or class 5 change (see the figure). These two categories carry the highest level of difficulty ratings because changing the implementation language has a major impact on the existing software. The conversion process under such circumstances affects potentially every line of the code. Thus, as many have expected, converting existing software into Ada will not be a simple procedure.

The Federal Conversion Support Center, established in 1981, can offer some help. It functions as a service bureau, providing guidance to federal agencies performing conversions, and as a clearinghouse for information pertaining to various aspects of software conversion. The center surveyed recent participants in conversion projects and, in January 1983, published a report entitled *Software Conversion Lessons Learned* (OSD/FCSC-83-003), which summarizes its findings.

The conversions surveyed were primarily changeovers from one hardware configuration to another, with no accompanying changes in language. Nonetheless, those responsible for rewriting programs into Ada can benefit from the center's findings, for the problems encountered are characteristic of conversions in general. Principal among the shortcomings identified were:

• Insufficient emphasis on detailed planning

verted software.

The center also found that programmers could satisfactorily convert straightforward, batch-type programs by simply recoding them. However, converting on-line and data-base programs required rewriting and restructuring because of changes to the environment for which the program was originally written. Conversions to Ada will fall into this latter category too.

The government as yet lacks experience with conversions to Ada. But, like the survey just cited, an analysis of large-scale conversion efforts under way offers insight into problems which can be anticipated. One such Air Force project involves replacing more than 200 base-level Univac U1050-II and Burroughs B3500, 3700, and 4700 computers worldwide with Sperry Univac 1100-60 models. This replacement effort is the main element of the service's base-level data automation program, officially short-titled Phase IV.

Installation of the new equipment and conversion of the associated software began in 1983 and should be complete in late 1985. Phase IV conversions primarily require recoding COBOL 68 into COBOL 74, a class 2 or "difficult" conversion. Approximately 25 Air Force organizations are responsible for converting some 300 software systems, and program language statements total almost three million. The Air Force Automated Systems Project Office is responsible for managing the software conversion effort.

In its *Development Center Software Transition Guidance Package*, issued in 1982 and now being revised, the project office emphasizes the importance of preparation. And the focus of research being conducted at Texas A&M University in conjunction with the office is the effect of planning on the overall conversion effort. (See John D. Fernandez, "A Methodology for the Analysis of Programmer Productivity and Effort Estimation within the Framework of Software Conversion," unpublished Ph.D. dissertation, Texas A&M University, May 1984.)

Preliminary results indicate that an investment in preparation time pays off. The first two organizations that carried out conversions differed significantly in the emphasis they placed on planning for the conversion effort. The activity that gave less attention to preparation (despite the possibly greater complexity of the systems it had to convert) typically required about 500 more hours

		Language	Version
1 - average	A/B	L1/L1	VX/VX
2 - difficult	A/B	L1/L1	VX/VY
3 - most difficult	A/B	L1/L2	VX/VZ
4 - easy	A/A	L1/L1	VX/VY
5 - highly difficult	A/A	L1/L2	VX/VZ

entitled "Conversion of Federal ADP Systems: A Tutorial," prepared for the National Bureau of Standards in 1980, Joseph Collica, Mark Skall, and Gloria Bolotsky define three approaches programmers can follow in converting software. What differentiates one from the other is the basis for the conversion.

The source code, that is, the language statements of the system itself, serves as the basis for the *recoding* approach. In *reprogramming*, the system design—documentation which details requirements the programmer must satisfy to generate the source code—is the basis for the conversion. The basis for *redesign*, the third approach, is the system's functional specifications; they consist of documentation, prepared prior to system design, which sets forth the user's conception of the functional requirements of the software. Use of functional specifications as the basis for conversion insures that the system's functions remain unchanged.

Recoding is usually the approach taken in class 1, 2, and 4 conversions and is appropriate for batch or general-purpose systems. Reprogramming, most often done in projects involving on-line or data-base systems, is the customary approach to class 5 conversions. In the case of class 3 conversions, especially for embedded or complex systems, programmers will typically follow the redesign approach. All three approaches have applicability to conversion of existing DoD systems into systems implemented in Ada, and the ramifications vary with the approach taken.

Recoding into Ada involves a line-by-line conversion

tion programs that can handle major portions of conversion from one specific language to another do exist, however, and are widely used. The level of automation possible depends upon the similarity of the two languages involved.

Translation programs which automate as much of the process as possible are beginning to become available for use in recoding software into Ada. A research team at the University of California at Berkeley has already defined some specifications for Pascal-to-Ada and Ada-to-Pascal translators. Because the two languages are structurally similar (the original design of Ada was based on Pascal), Berkeley researchers were able to define two sublanguages, Pascal A and Ada P, which have a fairly simple one-to-one correspondence—reflected in similar syntactic constructs—between common semantic concepts.

In an article entitled "Ada as a Software Transition Tool," published in *SIGPLAN Notices,* November 1980, pp. 176-182, Gary L. Filipski, Donaly R. Moore, and John E. Newton discuss the method used in the translation. Given a valid Pascal program, for instance, the Berkeley team first translated it into its respective sublanguage, Pascal A; then converted the program from Pascal A to Ada P, and finally generated a valid Ada program. Additional research will be necessary in order to determine the level of automation possible and to produce the translation programs.

Also needed will be automatic translation programs which convert software written in other languages such as COBOL, FORTRAN, and JOVIAL into Ada. Two principal factors complicate the design and construction of these programs, however. First, the basic syntactical form of Ada is quite different from that of other languages. For example, Ada is a strongly typed language; it requires that each variable used in the program be declared, and it does not allow implicit mixing of types. Thus an operation between an integer and a floating point in Ada is illegal without code that explicitly converts one to the other. Other languages do not impose this requirement and indeed often use mixed typing as part of the algorithm for the application.

The second complication derives from the numerous advanced language constructs in Ada, such as tasking and generics, which simply do not exist in other languages. Incorporating these advanced features into

written in Ada.

Given the limitations of the recoding approach, reprogramming and redesign are more attractive alternatives in conversions to Ada. Because the latter two approaches use specifications, rather than source code, in generating the new software, programmers can take advantage of advanced features of Ada such as tasking and generics. Both alternatives require more time to implement than does recoding but produce more efficient programs.

Reprogramming ranks in difficulty between recoding and redesign. In order to analyze the system being converted, programmers must work from existing design documents; therefore, little of the conversion can be automated. Although the functions and algorithms remain the same, the rewritten program may include new code with different logic.

The most difficult approach to conversion is redesign. Analysts must first develop a new design specification before programming can begin, and the new specification may use different algorithms, logic, and program structures. Manual conversion is the rule in redesign projects; only rarely is use of an automatic translator possible. However, redesign does allow programmers to take maximum advantage of advanced features of the new language or environment and to incorporate any recent developments in algorithms.

Redesign is the best alternative for embedded computer applications, that is, for those in which the system itself is part of a larger technological unit such as a weapon system. But analysts responsible for redesign projects must take care to produce an efficient code because of memory limitations of the computer and because of the critical importance of timing if the embedded computer application is to synchronize with other onboard systems. Inefficient code can result in saturated memory and in processing which is too slow for real-time applications. (See John H. Manley, "Embedded Computers—Software Cost Considerations," AFIPS Conference Proceedings, vol. 43, National Computer Conference, Chicago, Illinois, May 1974.)

A software conversion effort may involve one or some combination of the three basic approaches. In the case of conversions to Ada, programmers will be able to simply recode some of the existing software. However, these. Because Ada is a new language, a pool of programmers fluent in it has not yet been formed. Many colleges and universities are beginning to offer courses which include hands-on Ada experience, and thus the number of people familiar with Ada is increasing. Over the next few years, however, planning for conversions to Ada should include special provisions for teaching the language to programmers.

In light of the prevalence of programming languages such as COBOL, FORTRAN, and assembler, training conversion programmers to code in Ada takes on added significance. COBOL and assembler are the two most widely used languages in the commercial sector, and embedded computer systems typically use either assembler or FORTRAN. These languages have therefore helped define the language mind-set of the 1970s and, like their natural counterparts, have provided a framework for thinking. Computer languages of the past, however, limit the imagination and thinking of computer professionals to those ideas which can be implemented using them, that is, to the language mind-set they support.

Ada, on the other hand, provides a medium for programmers of the 1980s and 1990s to analyze, formulate, and express new and larger concepts and new approaches and opportunities. It is a product of 20 years of language research and accommodates the state of the art in both hardware and software technology. Programmers experienced in older languages must not only learn Ada as a new language but also develop a new mind-set or approach to programming which permits the expression of modern technical ideas.

In planning large-scale conversions to Ada, the reusability of software components is another key consideration. Reusable software improves both the quality and maintainability of a system. Project personnel need to conduct a functional analysis of the existing system in order to identify frequently used functions. They can then develop Ada software components for these functions and use the components in future programs that are produced by combining standard software elements. (See Anthony I. Wasserman and Steven Gutz, "The Future of Programming," *CACM,* March 1982, pp. 196-206.)

Ada program components which satisfy the functional requirements of existing programs can thus be in-

ing and redesign conversion techniques. gement is also important to the conver- fact, according to Barry Boehm (*Soft- ing Economics* (Englewood Cliffs, NJ: 1981), p. 486), poor management in- e costs more than any other single factor. berg has found that management of con- s tends to pose more problems than do spects (*Conversion of Computer Soft-* od Cliffs, NJ: Prentice-Hall, 1983), p. typical software development project, quires more discipline and stricter procedures. It may well resemble an operation. Successful completion often akdown of the total effort into well- hich depend upon experience and strict ocedures rather than innovation and in-

is usually not an assignment that rogrammers welcome. Managers tend to jects because they have neither planned or them (see Paul Oliver, "Guidelines to version," AFIPS Conference Pro- 47, National Computer Conference, June 1978, pp. 877-886). In addition, have to carry out the conversion in a with as little disruption to the ongoing ble.

st also deal with programmers who view h equal disdain because it is a less challenging task than writing new code. ounding the difficulties, managers need nd prepare for this problem. Involving the early stages of conversion is one em feel more a part of the total project. results under the Air Force's Phase IV e that efforts to manage the program- ave been successful. However, among ho converted programs they wrote or iliar with, some tended to perform odifications or enhancements during the cess. As a result, these knowledgeable ave sometimes required more time to work, and Phase IV managers have in- fforts to insure that the success of the jeopardized by programmers making

the converted programs are compiling and producing the required output.

This approach is both less costly and less risky. If the resulting system operates within specified time and space constraints, the code can stand as is. In the case of applications that cannot tolerate degradations in time or space requirements, the programming staff will have to make adjustments. Planning for a conversion should include appropriate allowances for such changes.

The tremendous investment in existing software and the high cost of developing new programs combine to make conversions an attractive alternative for the movement of systems from one environment to another. Ada is a present reality, and both DoD and other government agencies should begin preparing for implementation of appropriate systems in Ada. For assistance, planners can consult the Federal Conversion Support Center, which will furnish general guidelines, and they may also benefit from the Air Force's experience under the Phase IV project. Programmers still need tools and techniques tailored to Ada conversions, however, and developing them will require additional research. DMJ

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fast-payback projects

By ROBERT A. STONE
and
STEVEN N. KLEIMAN

Two new capital-investment programs designed to pay for themselves will enable DoD components to improve operations while slashing costs.

The Department of Defense knows that the quality of military installations directly affects the department's ability to carry out its mission. As Secretary of Defense Caspar W. Weinberger stated in his October 5, 1983, memorandum to the secretary of the Army, "Continuing high priority on facility investment for th next few years will result in decades of strengthened na tional defense." On a practical level, maintaining tha priority requires resources, and DoD has set up two ne programs, the Defense Relocation Program and the Se

PHOTO BY JERRY HEALY, U S

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PHOTO BY JERRY HEALY, U.S

portunity to benefit from managing their business more efficiently and effectively. Formulated and administered by the staff of the deputy assistant secretary for installations, the two programs seek to alleviate chronic funding shortages among facilities and services projects.

Because DoD's spending authority is limited, often only the highest priorities receive funds. The following scenario is typical.

A base commander or base engineer believes that his or her organization can be made more productive and efficient by relocating certain functions and physical assets, perhaps by consolidating dispersed training facilities. To carry out the project, headquarters must provide funding to pay up-front costs associated with design and construction. The organization therefore prepares a cost justification package outlining the advantages of the project, the savings that will accrue, and the productivity enhancements that will result. Headquarters reviews the proposal along with other very worthwhile projects competing for funds, but finds that it does not have enough dollars to go around. So, try again next year? Not necessarily.

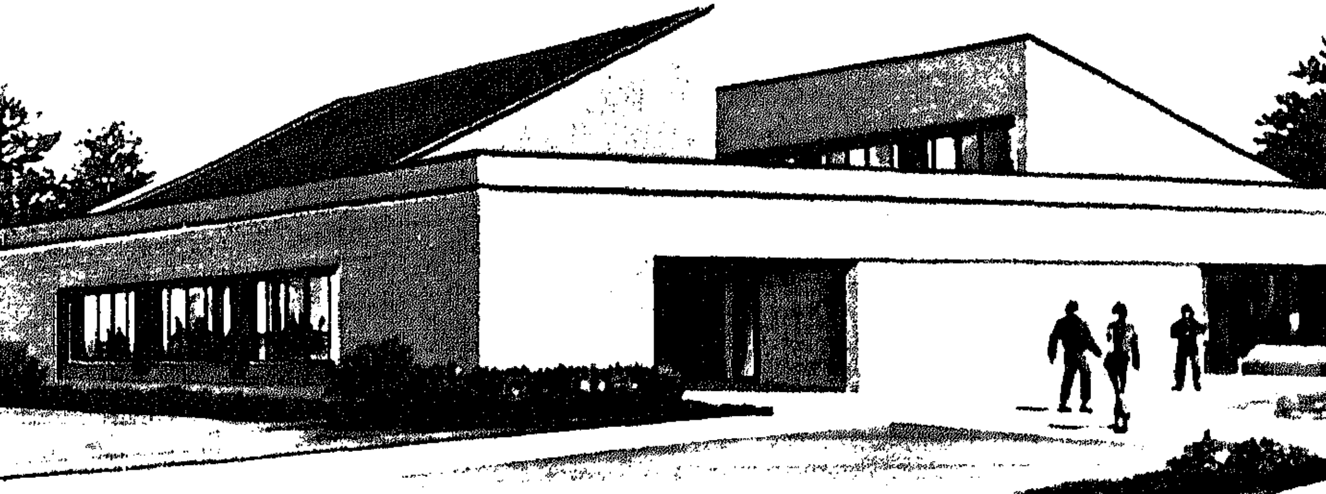
The Defense Relocation Program is another option to consider. The Defense Resources Board established this

each budget year for the military departments and defense agencies, it plows outyear savings (and budget year savings, if applicable) back into the program. This rotating fund approach—pay out up-front costs and recover outyear savings—replenishes the fund so that moneys are available for future projects. In other words, the program is self-perpetuating.

What criteria do reviewers apply when evaluating candidates for funding? The first consideration is return on investment. A project must yield substantial savings over and above initial outlays. Proposals that will result in personnel reductions, for example, or lower utility and transportation costs, save operation and maintenance dollars. Vacating leased space for government-owned space can also mean real dollar savings.

Projects such as these free funds for redistribution to other worthwhile programs. Proposals designed to improve productivity and boost employee morale also of

Under the Defense Relocation Program, the Army will spend $2.5 million in FY 1985 to consolidate six company-size dining facilities at Ft. Bragg—"temporary" buildings of World War vintage like that shown at left—into a single building like that depicted in the artist's rendition below.



Belvoir and two leased buildings in Falls Church, Virginia. Construction of the new $31.2 million support facility will eliminate leasing costs at the two Falls Church buildings and provide additional savings from the backfill of buildings vacated on Ft. Belvoir. Personnel savings and decreases in maintenance and utility costs will amount to approximately $6.4 million per year.

During the first two years Defense Relocation Program funds have been available, the services also submitted numerous proposals to relocate recruiting commands from leased to government-owned space. Typically, these and other very worthy projects failed to satisfy one of the program's major criteria—rapid payback. They did not generate sufficient savings to recoup initial outlays within five years.

Like the Defense Relocation Program, DoD's Sell and Replace Program rewards efficient and effective installations management. Legislation enacted by Congress in fiscal year 1984 permits the Defense Department to sell nonexcess real property under its control and use the proceeds to replace facilities that had to be relocated in order to sell the land. Congress has authorized $50 million for the program in fiscal years 1985 and 1986.

The secretary of defense will administer the management account now being established for the Sell and Replace Program. At the request of the military services, the secretary may propose to Congress the sale of any real property under the department's control. He can also recommend land acquisition, construction of replacement facilities, and relocations required to insure continuity of defense functions.

A hypothetical example will help illustrate the potential benefits of the program. In a county or municipality that has been undergoing rapid urbanization, an installation might find that its 35-year-old headquarters building, once nestled in the woods, is now contiguous to a new office park and shopping mall. The building and land it sits on have become very valuable. Relocating to the other side of the base would require approval to acquire additional real estate and build a new structure. Under the Sell and Replace Program, an installation can do just that.

DoD can turn over land, with its structures, to the General Services Administration for sale and use the

ness interests are well-served.

The Sell and Replace Program is particularly usefu for disposing of land that has very high market valu and relocating displaced facilities to less costly sites. It i adaptable to a variety of needs as well, and DoD i developing guidance for the program which will ensur that the review and approval process is compatible wit the budget process.

Both the Sell and Replace and Defense Relocatio Programs give the base commander and the base engi neer great latitude and flexibility in providing a mor efficient and effective working and living environment Each offers the savvy manager an opportunity to im prove operations while cutting costs. The task that re mains is to use the new incentives creatively. DMJ

ROBERT A. STONE has served as deputy assistar secretary of defense (installations) in the office of th assistant secretary of defense (manpower, installatior and logistics) since 1981. In that capacity, he manage planning, programming, budgeting, and operations fo all DoD installations; his other responsibilities inclua DoD's A-76 commercial activities program and env ronmental impact matters affecting defense operation. Prior to assuming his current position, Mr. Stone wa acting assistant secretary of defense (manpower, reserv affairs and logistics) and also served as deputy assistar secretary of defense (program management). Befor joining the Defense Department in 1969, he was a re search and design engineer in private industry for sev eral years. In 1980, Mr. Stone received the presidenti Meritorious Executive rank. He holds bachelor's an master's degrees in chemical engineering from the Ma sachusetts Institute of Technology.

STEVEN N. KLEIMAN has been a managemer analyst in the office of the deputy assistant secretary c defense (installations) since 1982. He is responsible fc developing, assessing, integrating, and evaluating plar and policies in support of major programs affectin DoD installations. His duties include managing and ac ministering the Defense Relocation and Sell and Replac Programs. Previously, Mr. Kleiman was the director c the office of planning and management, Defense Co tract Administration Services Region, Atlanta, Georgi He earned a bachelor's degree in economics fror

A boost for defense managers: some uses of computer graphics

By JOSEPH S. BROWN

Computers can do more than crunch numbers and process words, and busy, cost-conscious managers stand to benefit greatly from new applications such as computer graphics.

It represents a radical break with tradition. A reshaping of the conventional mold. Definitely not business as usual.

Computer graphics, as applied to defense-related design and engineering projects, is saving money and time and simplifying many managerial tasks as well.

Enlisted personnel at two Navy facilities—the service's New London, Connecticut, submarine base and its Great Lakes, Illinois, training center—are now occupying new housing units designed using computer graphics. The computer-aided design for the housing prototype attracted a construction estimate nearly 7 percent below the government's figures, which were based on conventional design methods. Approximately $600,000 of the savings was attributable to economies resulting from computer-aided design.

For the Army Corps of Engineers, Everett I. Brown Company, the architectural and engineering firm on the Navy project, is using computer graphics to develop complete design drawings for some 30 building types—from barracks to battalion headquarters. Individual Corps districts will site-adapt these designs to suit differences in location, availability of materials, and other regional variables, thereby saving six to nine months of design time on a project. With up-to-date building plans easily accessible, the Corps will also be able to expedite construction of facilities in support of military surge requirements.

Benefits accruing to the Army and Navy projects are

Graphics, of course, is essential in architecture, engineering, and related disciplines; it supplies a primary communications link between project participants. Computer graphics does the same, but uses the computer as a tool to facilitate what had previously been done manually. "Drawings" originated on a video terminal replace those done by conventional pencil-and-paper techniques.

Basically, computer graphics permits the manipulation of symbols—lines, geometric figures, and so forth—and alphanumeric characters on a video display screen. Graphic data can be entered into the on-line digital design file in several ways: by a cursor moving across the screen, by key-in from the system keyboard, by retrieving stored information from the computer's memory bank, or by using either a digitizer (a device that converts graphic information into digital form) or a laser scanner to copy existing drawings and text. The output can be a screen image, a pen-and-ink plotter drawing, or a printout of an electrostatic paper image.

But beyond providing a drafting function, computer graphics facilitates a wide range of other tasks as well. For military and government officials with facilities planning, construction, and management responsibilities, computer graphics speeds the task, helps assure accuracy, and improves cost controls during the life of a project and, because of the data base it provides, afterward as well.

On the military projects cited above, the Brown Com-

But hardware is only the beginning; applying it systematically provides the payoff. For example, combining photogrammetric mapping and computer graphics produces digitized drawings of installation master plans and potential construction sites. This combination of site information and basic building designs, which is part of the computer's data base, enables the Corps of Engineers to mobilize construction activity without time-wasting preliminaries.

The benefits extend even beyond the construction stage. For instance, computer-aided design makes possible a digital record of a facility "as built," which aids in post-construction maintenance and management. Although the same information can be laboriously compiled and updated by conventional methods, computerized records are centrally located, are readily accessed by multiple users, and occupy minimum storage space.

The human interface with the system includes computer graphics operators, graphics and photogrammetric applications specialists, data processing support personnel, ground survey parties, architects and engineers, and other technicians and support personnel. These people and the equipment they operate are vital system components, and they in turn are critically dependent upon the software that makes the system tick.

Software, as opposed to the physical equipment or hardware, comprises the programs, languages, and procedures necessary to enter and process the information. Unlike software for more familiar number-crunching and word processing applications, graphics software is not readily available in turnkey packages for many architecture and engineering applications. Consequently, much of it must be developed from scratch, and most of this application-oriented software originates in the private sector, either independently or in response to military and government requirements.

Another component of the computer-aided design system is the set of graphic symbols peculiar to architecture and engineering. Contents of the Brown Company's computerized data base number more than 3,000 cells of frequently used symbols and design details. Electrical circuit symbols and standard wall-section details that can be "plugged in" when needed are examples.

These symbols are the modular building blocks for

vantage over manual methods.

The scope and complexity of many large defense construction projects have, in some cases, made computer graphics capability a necessity for architecture and engineering firms seeking such business. Announcements in *Commerce Business Daily* are increasingly specifying contractor capabilities that include computer graphics. The General Accounting Office is also aware of the cost, time, and energy savings possible through computer graphics applications. In a report entitled *Agencies Should Encourage Greater Computer Use on Federal Design Projects*, issued on October 15, 1980, GAO stated: "In comparison to manual design methods, computers can enable designers to produce higher quality, more effective facility planning and architectural designs; reduce the amount of energy consumed by buildings; and lower overall building costs through reduced construction, maintenance and operating costs."

Cost reduction opportunities are both short- and long-term. Because of its speed and instant access to previously developed information, for instance, computer-aided design cuts near-term administrative costs. Thus, on the Navy barracks projects described earlier, a remote graphics workstation at the Naval Facilities Engineering Command linked the client in Philadelphia to the contractor's data center in Indianapolis. On-demand, ongoing project review was possible without the burden of travel and per diem expenses for either the Navy or Brown Company personnel. The firm estimated that savings to the government in travel costs amounted to $10,000 for each project.

In project design, computer graphics generates the greatest savings in the area of repetitive drawings, particularly electrical schematics and wiring layouts. Compared to conventional manual methods, computer graphics can save time on the order of 8-to-10:1 or more, and it can also pay substantial dividends when applied to architectural, structural , and civil design work. On the New London and Great Lakes projects, for example, computer graphics techniques cut overall drafting time by 20 percent to 25 percent (approximately 2,600 manhours), slashing 50 percent (1,000 manhours) from electrical drafting time alone.

Both of these Navy housing projects incorporated standard sleeping room modules. Design changes such

and television producers to enhance three-dimensional visualization.

In addition, computer graphics helps project personnel identify interferences caused by faulty location of structural and support systems. For example, an engineer may inadvertently locate a ventilating system in space occupied by a structural column. When the staff merges the independent computer "drawings" of each of these systems—in effect, lays one on top of the other—they can quickly spot such obstructions. In the Brown Company system, 63 levels of overlay are available, each representing a separate system. By reducing the chance of error in the design stage, this feature minimizes costly construction rework and delays.

Computer graphics has useful nondesign applications as well. Personnel can attach non-graphic descriptors, known as attributes, to any of the data and recall them with that data instantly. The specific attribute might be a specification or identification number, a name for a bill of materials, a manufacturer, material finish, color, physical spec, cost, date installed, or component of a critical path. Through attribute attachment, a data base develops as the plans evolve. Users can readily recall reports summarizing pertinent information on specified subjects.

Better design quality is another benefit of computer graphics. Computer-aided design reduces the potential for error by eliminating manual drudgery in drawing and revising. It also facilitates tasks such as selecting optimum systems for energy efficiency. Technicians can run through multiple "what if" combinations of materials, equipment, and technologies to quickly evaluate alternatives. In one application of the what-if technique, a Brown affiliate is employing computer-aided design at Fort Jackson, South Carolina, for master facility planning, including site analysis. When changes are necessary, updating a magnetic tape record of the design automatically maintains the currency of all materials printed from that tape.

The as-built record provided by a computer-aided design system is particularly well-suited for managing military logistics support systems. Tracing utility and phone lines, for example, is simplified by the ready availability of this information in computer storage files. Similar data aid fire protection, security, and space utilization management.

calculations, and that the final data be part of a cross-referenced system that permits quick assembly of drawings and related information in the event of need.

Just as the concept of standardized building designs has proved valuable in the private sector for structures ranging from schools to fast-food snack shops, it is also beneficial in meeting military requirements. Standardized designs reduce overall design costs, speed the design process, facilitate accurate bid evaluation, and simplify specification and procurement of furnishings, other necessities, and amenities.

Although building designs for the Corps are standardized, staff engineers, using computer-aided design techniques, can readily tailor them to fit the site. The Corps can specify heating and other mechanical systems as well to ensure that they accommodate local requirements, preferences, and cost factors. In the near future, they will have the ability to adapt designs to local architectural style preferences, use locally available materials and trade skills, and reflect other site-specific variables:

- The Corps can alter architectural style to blend with existing structures, whether the project is located in the hills of New England, the arid Southwest, or semi-tropical Florida.
- Similarly, the user can select an exterior finish—metal, brick-and-block, concrete, wood, and so forth—that complements the architectural style and employs materials common to the area.

Computer-aided design even permits modification of the basic structural design. The Corps will be able to reinforce buildings constructed in the Pacific quake belt to withstand seismic shocks and can strengthen those in the Gulf Coast's hurricane alley to withstand frequent high wind pressures. Structures based on the same standard designs may thus be strikingly different due to the variables mentioned. Because computer-aided design allows easy manipulation of alternatives, basic designs can meet a variety of needs.

Despite all these advantages, less than 40 percent of the private-sector architecture and engineering firms in the U.S. use computers for anything; fewer than 5 percent have any computer-aided design capability at all. Why?

In part, the answer is that design-oriented architects have been much slower than number-oriented engineers to explore the potential of the computer. Also, many

uter-aided building design eliminates much of the ex- ' redrafting and creates a digital record of a facility "as vhich aids in post-construction maintenance.

ter-aided design.

of a data base has hindered the changeover as uilding up a complete library of graphic stand- ay take years. Difficulty in converting drawings al form has also been an impediment in develop- mputer graphics data bases from existing, ly drafted drawings.

ough both hardware and software costs for com- raphics can be substantial, a third item, person- 1 equal the costs of the first two combined and both military and civilian use of computer s. People-related expenditures include time and for initial selection and training of computer s operators and substantial outlays for periodic ng. Continuing education is necessary if person- to stay abreast of new developments in the e, growing technology that supports architec- nd engineering applications.

1 these obstacles, why then do architects and rs hold computer-aided design in such high favor h civil and military applications? A principal is that it enables them to digitize data from every f the life cycle of a structure—from site search aluation through aerial photography and con-

tinue as well; in electric circuit tracing, for instance, printouts providing the complete maintenance history of the circuit will become available. Space planning and space management applications, which take advantage of non-graphics attributes attached to furnishings and equipment, hold promise as well.

The future will also see development of more user-friendly software. As the capabilities of computer technology become easier to use, applications of computer-aided design will become more numerous. What's more, as higher-level programming languages become available, training time for computer graphics operators will decline and productivity will rise. Presently, entry-level training time is two months, and it takes four additional months for an operator to achieve journeyman status. Development of increasingly sophisticated programming over the next several years should reduce the overall training and learning cycle to three months.

User-friendliness can grow in another context too. Regardless of the hardware or software employed, management can make any computer-aided design system more user-friendly and nonthreatening to personnel by the way in which it introduces and implements the system. Flexible rules on the use of graphics capabilities, for example, can stimulate designer creativity.

Finally, by interfacing computer graphics systems, the military and civilian sectors can achieve far greater mutual cooperation. The Brown Company's work with both the Navy and the Army illustrates the benefits of such cooperation. Design time has increased significantly, two-way data and graphics communications have saved time and money, construction costs are potentially lower, and an ever-increasing library of plans and graphic symbols is available to ease many management chores. For both military and civilian applications, computer graphics holds great promise and has already begun to deliver. DMJ

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Fielding future weapons: mandate for logistics research

By COLONEL JOHN C. REYNOLDS, USAF
and
MAJOR FRED G. SALIBA, USAF

The Air Force is strengthening its commitment to logistics research and to incorporation of the results early in the development and acquisition process.

cs support has traditionally been a silent er in weapon systems research and develop- reased performance has been the paramount a acquiring new systems; the role of the logis- unity has been to provide support capabilities se to predetermined design characteristics and ent strategies. Thus logistics capabilities have ehind performance capabilities rather than lving with them or contributing to them. As a apon system support today tends to be highly zed, relatively immobile, and manpower- and t-intensive. Such a support posture, however, eet the needs of the 21st-century warrior. The will face is likely to be an unexpected crisis in a ouble spot vulnerable to disruption of supply communication.

quate response to that threat will require that ike cost, schedule, and performance, be ac- e status of senior partner in the acquisition To that end, the Air Force has established a logistics research and development program. ice's Coordinating Office for Logistics in conjunction with the Office of the of the Air Force, the Air Force Systems Com- d the Air Force Logistics Command, ad- the program. It carries out long-range plan- ponents of the program and explain the dramatic impact it can have on design and support of future weapon systems such as the Advanced Tactical Fighter. It will also define tasks remaining to make the newest senior partner in weapon systems acquisition a fully effective contributor to the warrior's advantage in the 21st century.

The logistician's mission has remained essentially unchanged since Neolithic man began using rocks as weapons. His responsibility is to provide the right mix of weapon systems, at the right time, in the right place, and in the right numbers to support the commander's plan of attack. However, the application of technology to the warfighting arena has greatly complicated that task. While weapons technology evolved relatively gradually up until the 20th century, it has in effect exploded within the short space of a hundred years. To keep pace, obviously, logistics support systems can no longer evolve arithmetically.

Moreover, a mismatch between support systems and weapon systems can be fatal. Leaders who have ignored or underestimated the importance of logistics have often undermined otherwise enormous military advantages. Napoleon's and Hitler's separate ventures into Russia are perhaps the best-known modern examples of setbacks resulting from ill-equipped or ill-supplied forces.

technological advantage, and striking a balance between hardware capability and numbers on the one hand, and support of those weapons in a time-sensitive, worldwide environment on the other, must be the fundamental objective. For the future promises a world in which the warrior's advantage will not depend solely upon speed, payload, range, and target acquisition, but upon space, time, and environment as well.

Norman R. Augustine, who has served as assistant secretary of the Army (research and development) and chaired the Defense Science Board, has made this point vividly:

> *Advanced night vision systems have already denied concealment by darkness, and attention is turning to peeling away the cover of weather as surely as one peels away the layers of an onion. It thus seems likely that soon the only remaining places to hide will be in "deep" space, under the water or under the ground. . . A major aim of the 1980s will be to eliminate these last sanctuaries. . . If the 1970s witnessed the advent of military systems that will hit their intended targets and the 1980s can be expected to construct the ground work for finding the target, what then remains? To survive! ("A Look into the Future,"* Army Research, Development and Acquisition Magazine, *January-February 1982, p. 22.)*

To provide support systems adequate to such an environment, the Air Force Logistics Research and Development Program attempts to capitalize on technology, present and future. The program comprises several key components. The first is logistics long-range planning, the umbrella under which other program components operate. Based on a twenty-year forecast, this process encompasses a systematic effort to provide broad planning guidance, in the form of goals and objectives, for developing future capabilities.

As currently stated, Air Force logistics planning goals are:

- To organize for wartime operations and to conduct peacetime operations within that framework.
- To be able to support U.S. forces engaged in varying levels of conflict, whether independently or in concert with other friendly nations.
- To include logistics at the front end of all Air Force

translate them into a number of specific objectives. Some of these relate to the potential of new technology for remedying current problems or meeting future needs. Others lend themselves to the research and development approach for finding solutions to logistics problems. Examples of long-range planning objectives include:

- Providing weapon systems with logistics design characteristics that meet warfighting requirements.
- Making logistics supportability an acquisition criterion equal in importance to cost, schedule, and performance.
- Improving the productivity of organic operations that support wartime requirements.
- Developing logistics capabilities for deploying and sustaining combat forces in various types of war scenarios.

A "call to the field," issued annually by the Air Force deputy chief of staff for logistics and engineering, initiates the effort to identify logistics research and development requirements. This call allows the major commands, separate operating agencies, and Air Staff organizations to assure that the research base accommodates logistics-oriented research and development needs.

As the primary manager for Air Force research and development programs, the Air Force Systems Command also plays a role. Other major participants in the service's logistics research and development program are the Air Force Acquisition Logistics Center and the Air Force Logistics Command. The former, for example, provides half of the coordinating office's manpower through "dual-hatted" engineers who constitute the office's total engineering sciences capability.

Once identified, requirements are forwarded to the coordinating office for logistics research, which collects, assembles, consolidates, and integrates individual organization submissions, as necessary, into a comprehensive package. Appropriate processing within the logistics community follows, and Air Force headquarters then forwards the package to the vice commander, Air Force Systems Command, for formal insertion into the laboratories' planning and programming cycles.

ability considerations in acquiring weapon systems, the Air Force has been identifying experts throughout the logistics community and adding them to lead-service laboratory evaluation teams responsible for contractor on-site reviews. In addition, through papers, symposia, professional societies, and industrial associations, service personnel continue to remind the acquisition community that supportability is coequal with cost, schedule, and performance. Fortunately, contracts, technical plans, and other proprietary independent research and development documents are beginning to reflect substantial increases in logistics-oriented research.

The need for such projects is urgent. In the face of critical manpower and strategic material shortages, the current fixed-site support structure, which relies heavily on people and equipment, will obviously limit effective employment of 21st-century air power. Other logistics challenges that the future holds include the unpredictable timing and location of conflicts, the vulnerability of airlift and sealift, the susceptibility of command, control, and communication to disruption, and the reduced sanctuary of air bases.

In 1982, Air Force headquarters issued a study entitled *Air Force 2000: Air Power Entering the 21st Century.* That study cites three major characteristics as essential to the service's operational support structure in the next century—mobility, flexibility, and survivability. Readiness and sustainability will require that sufficient quantities of spares, munitions, fuels, and other items, as well as the trained manpower to use them, be readily available in the Middle East, South America, or wherever our rapid deployment forces are tasked to go. Presuming that shortages are overcome, logisticians will have to determine how to get the material, equipment, and people to the deployed location in time to sustain operations. Nor will the challenges stop there. Once in place, how will the various support entities function in projected chemical, biological, and radioactive environments? And will dedicated command, control, and communication lines and distribution be available to sustain them?

Clearly, planners are going to need substantial help in developing a posture that can support complex weapon systems in such an environment, and logistics research and development must be ready to respond. Through in-

achieved by exploiting technology for reliability, maintainability, and suitability.

• Production-oriented, decentralized weapon systems maintenance, to be accomplished by distinguishing between on-equipment and off-equipment maintenance processes.

• Improved logistics resourcing, to be effected through more rigorous requirements determination and improved management and distribution systems.

The Air Force's Advanced Tactical Fighter illustrates that the potential exists to realize these goals. Conceived as a system to meet the threat expected in the 21st century, this aircraft will require a support concept that makes quantum leaps in reliability and maintainability. Logistics-oriented research, and the technology deriving from it, must focus on these two key factors in order to achieve the mobility, flexibility, and survivability that the threat environment will demand.

The discussion below will explain what the Air Force logistics community can do to formulate a support concept, based on logistics research and development, that "flies in formation" with the weapon systems research and development program. The focus is on maintenance and maintainers but does not discount other elements of the logistics equation such as acquisition, requirements computation, assured distribution, and facilities. Because maintenance and maintainers always deploy with the system, they represent either substantial constraints on or enhancements to the warrior's advantage in some far-flung corner of the world.

The basis for all maintenance documentation is engineering data, which are fundamental to designing any support concept. They are the engine that drives the number of personnel, skill levels, training, and level of responsiveness needed. Historically, however, engineering data have been ill-defined, badly produced, and bought several times. Presently, Air Force maintenance documentation consists of millions of 8" x 10" sheets of paper assembled in binders called technical orders. Developed, printed, and purchased for billions of dollars, these orders receive worldwide distribution because someone might need to use them to perform maintenance tasks ranging from routine servicing to complicated, unscheduled repairs.

But today's technology affords the Air Force an op-

ermit not. Air time update of technical data bases nywhere in the world through the most survivable communication links (either satellite or ground-based packet-switch networks). Both technologies—interactive data bases and digitally distributed networks—have already been validated.

Electronics and integrated circuits technology are two other rapidly advancing fields that hold great promise for logistics-related research and development and, in particular, for the Advanced Tactical Fighter. Three areas ripe for exploitation are built-in diagnostics, graceful degradation, and transparent technology.

Built-in diagnostics employs built-in test and fault-isolation test capabilities. By working with validated and near-validated technology, available in large-scale integrated circuits and very high speed integrated circuits, the Air Force can design undreamed-of increases in reliability and maintainability into the Advanced Tactical Fighter.

Graceful degradation will also make possible quantum leaps in reliability. The concept involves using digital signal processing and redundancy so that a system can degrade without the warrior perceiving any degradation. The maintainer, however, will sense it by means of on-board recorders and test circuits, thus eliminating the maintenance urgency of a grounded aircraft. Moreover, on-board systems, tied to live data bases, will direct the maintainer to the exact problem, rendering troubleshooting obsolescent. By combining interactive data bases with on-board diagnostics,

already yielded handsome returns and can fur enhance the warrior's advantage. Applied properly, results can free him from the severe constraints characterize logistics support in the traditional mo The technological breakthroughs described above m appear in either new or modified aircraft even bef being applied to the Advanced Tactical Fighter.

Support equipment is one other area in which the Force can very profitably pursue logistics research, significant improvements are within easy reach. Toda weapon systems require a wide array of ground supp equipment, from avionics intermediate test sets to liq oxygen plants. These requirements either tie the warr to a fixed infrastructure or demand huge amounts strategic airlift to move the support tail and associa personnel. However, recently validated or matur technology could dramatically reduce portions of burden.

Multifunctional integrated power units, for examp may be a feature on board the Advanced Tacti Fighter; if so, ground starting units, generators, a other support equipment will no longer be necessa Applying kidney dialysis technology, researchers c also split free air into breathing oxygen and inert g and channel the latter into fuel systems as a fire suppr sant. Such a system on board an aircraft would impos very small weight penalty and eliminate the need liquid oxygen and liquid nitrogen.

What the using commands and the logistics commu ty must do is drive these validated technologi

Reginald Jones, the recently retired chairman of the board of General Electric, has described the onset and impact of this way of thinking:

> *We have consciously sought to elevate the lawyer and accountant to the Chief Executive Office (CEO) positions of our corporations. By doing this, we have brought a short-term return on investment strategy to our corporate structures. This strategy demands an improvement on this quarter versus last year's quarter. It stifles growth and capital investment and is killing us in the international marketplace. ("Playing It Safe and Losing Out,"* The Washington Post, *January 17, 1981, p. A-1.)*

The Department of Defense adopted this strategy during the 1960s and, over the years, it has permeated DoD under the guise of the planning, programming, and budgeting system. The logistics community will have to weigh it carefully when considering ways to institutionalize the new senior partner. Executing the transition from supportability rhetoric to reality will require a strategy that emphasizes:

• Integration of logistics long-range planning with Air Force and Joint Chiefs of Staff programs.

• An awareness of and commitment to using the statement of need to drive supportability for the weapon systems concept. That document offers the using commands a vehicle for insisting that the concept development phase for any system consider validated and potentially available logistics-related technologies; users must be aware of such technologies and trust the system to produce them.

• Development of a logistics force structure that complements and enhances the warrior's advantage in the 21st century threat environment.

• Integration of logistics considerations in the very early stages of weapon systems design. Not only must the design engineer be fully aware of what supportability means in terms of his discipline, but contracts must also state logistics requirements in terms that can be measured, traded off logically, and enforced. This is the single issue that logisticians must articulate much more persuasively than in the past.

• Commitment to planning and funding logistics and weapon systems research and development together and supportability is a recognized criterion in determining the level of reimbursement by the government will contractors target this seed money, expended to enhance their competitive position in the marketplace, towards a reasonable balance between performance and logistics objectives.

• Establishment of financial and informational channels to promote incorporation of validated technology into both new and existing weapon systems. Resources must be available to fund transition from the laboratories into weapon systems, but first the labs must have a vehicle for disseminating information about available technologies in order to develop advocacy within the using commands.

The potential impact of logistics research and development on future combat readiness, that is, on the availability of weapon systems to perform as designed, cannot be overstated. To tap that potential, Air Force planners are seeking to institutionalize the new senior partner's role in weapon systems acquisition. They must succeed, or we run the risk of repeating the errors of Napoleon and Hitler. DMJ

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MAJOR FRED G. SALIBA, USAF, is chief of the plans and programs division in the Air Force Coordinating Office for Logistics Research. Before assuming that post, he spent ten months in the education-with-industry program at Lockheed-Georgia Company in Marietta, Georgia. Major Saliba is a graduate of the U.S. Air Force Squadron Officer School and the Air Command and Staff College. He earned a bachelor of science degree from the University of Tennessee and a master's degree in business administration from Oklahoma City University.

In the Fraud Update section of the First Quarter 1984 issue, the Defense Management Journal *reported on DoD's efforts to reduce spending and increase efficiency. In addition, the column identified several individuals and firms who pleaded guilty to crimes involving fraud. One of those firms knowingly supplied DoD with substandard parachute suspension cord.*

In light of such cases, I am concerned about the amount of newly purchased equipment that does not function properly and, even more importantly, about how the soldier's safety is jeopardized by this defective material. When officials of a company cheat on equipment in order to cut costs, they also may be cheating a soldier of his life. The soldier should not have to wonder whether his weapon will misfire because someone accepted a bribe or a kickback upstream in the procurement cycle.

We in the fighting force take this issue to heart because we are the most victimized by it. I am appreciative of the information you have published thus far, but I would like to see an update on the actual penalties imposed on those found guilty.

JERRY A. BOST
SP5, U.S. Army

In response to the foregoing, *DMJ* offers the following fraud case updates.

• Medical Devices of Fall River Inc., a Massachusetts firm, was ordered to pay a $15,000 fine for making false statements in order to obtain contracts with the Defense Logistics Agency and the General Services Administration. The company had promised to provide surgical instruments manufactured in the United States, but in fact provided instruments made in Pakistan. The firm's president was sentenced to six months' imprisonment on each of four counts of false advertising. Although the prison term was suspended, the president was placed on two years' probation and ordered to pay fines totaling $20,000.

• A former Navy lieutenant was found guilty of one count of conflict of interest and one count of making false statements while serving as a contract specialist then falsified records to indicate that components purchased from the company had been delivered when, in fact, they had not. He was placed on five years' probation and ordered to pay a $10,000 fine, make restitution of $8,100 to the government, and do 500 hours of community service. He also received a suspended four-year prison term.

• A former buyer at the Defense Industrial Supply Center in Philadelphia was sentenced to three years' probation and fined $2,000 for accepting $200 from a prospective contractor in exchange for confidential pricing information.

• The president of Lamar Electronics, a Vermont-based firm, was sentenced to six months' confinement and placed on three years' probation for filing false and fraudulent claims against the government.

• The president of Standard Air Parts, Inc., of Sylmar, California, was sentenced to four years' imprisonment and fined $208,000 after being convicted of mail fraud and bribery. The company was ordered to pay fines totaling $159,000.

• A California scrap dealer was convicted of mail fraud in connection with obtaining material from DoD property disposal offices. Using 15 aliases, the dealer intentionally passed bogus checks to the government at least 25 times. He was sentenced to five years' imprisonment and ordered to make restitution of $64,000.

• In what may be the largest civil health care fraud settlement ever, a former partner of a psychiatric hospital in Fayetteville, North Carolina, has agreed to reimburse the government $700,000. Concurrently, the Cumberland Psychiatric Institute, the practice the defendant owned half an interest in, will pay the government $1.25 million in reimbursement and penalties for fraudulent claims against the Civilian Health and Medical Program of the Uniformed Services. The fraud scheme comprised 241 claims depicting lengthy hospital stays at artificially inflated room rates. The hospital also submitted claims requesting government payment for treatment and services already paid for by the patient or the patient's insurer. As a condition of settlement, the doctor has surrendered his North Carolina medical license.

Getting what you bargain for

BY STEPHEN A. KLATSKY

This is the first of a series of columns on federal civilian personnel labor law and management-employee relations. Many of the principles outlined in the series derive from case histories and experiences at the U.S. Army Materiel Development and Readiness Command, the largest employer of civilians within the Department of Defense, where the author is the senior labor-civilian personnel law counselor. A member of the New York State Bar, Mr. Klatsky holds a juris doctorate from Albany Law School, New York, and a master of laws in labor law from George Washington University.

A federal agency should invest considerable thought and effort in establishing its objectives and preparing for collective bargaining, a process that involves negotiations between management officials and union representatives on personnel policies, practices, and the terms and conditions of employment. The task is a challenging one for federal managers, and they will find divergent schools of thought on the nature of the collective bargaining process.

The Congress, for example, in a preamble to the Civil Service Reform Act of 1978, stated that "the statutory protection of the right of employees to organize, bargain collectively, and participate through labor organizations . . . in decisions which affect them safeguards the public interest [and] contributes to the effective conduct of public business." But in the 1982 case of *General Building Contractors Association, Inc.*, vs. *Pennsylvania*, the U.S. Supreme Court sounded a different note. It observed, "The parties still proceed from contrary and, to an extent, an-managers and supervisors need to familiarize themselves with the collective bargaining process. By doing so, they can acquire the knowledge and skills required to participate effectively in it.

Bargaining goals. Collective bargaining is an integral part of an agency's labor-management relations program. Management establishes its collective bargaining goals during the unorganized (no union) state. Those goals evolve during an organizational campaign, when management, by keeping an ear to the ground, can learn what the union's approach to collective bargaining will be. Finally, management pursues the goals within the statutory and regulatory framework that defines its rights and obligations.

Although formally issued by an agency's director or commander, collective bargaining goals actually derive from input provided by managers and supervisors, who examine union proposals and policy positions and describe the impact their adoption would have on mission performance. First, therefore, management must compile, analyze, and review the collective working condition experiences of the activity. That exercise gives valuable historical perspective on the union's traditional reaction to agency personnel policies and on the effect those reactions have had on management's ability to satisfy job requirements.

Collecting the necessary historical data and documentation requires a systematic approach. Normally, the management-employee relations branch of the civilian personnel office conducts round-table discussions with division chiefs and heads of directorates to explain the importance of the data-gath-plinary procedures, grievance arbitration, and the right to union representation.

For each issue, management should review current policy and assess its strengths and weaknesses. A history of complaints or grievances by employees or the union often indicates a problem area. First-line supervisors should channel their thoughts on these issues up through the supervisory chain to the chiefs of the organizational elements. The results of this data collection effort help policy-makers decide which personnel policies and practices to retain, which to discard, and which to improve. The director or commander uses the data collected in formulating concrete and specific collective bargaining goals.

Getting ready. After establishing goals, management assembles its negotiating team. The key member of this team is the chief negotiator, who is responsible for articulating the rationale behind management proposals and, when necessary, objecting to or challenging union proposals. In addition to being fully conversant with collective bargaining policies and practices, the chief negotiator must be highly knowledgeable about the agency's mission, functions, and organization. Also, this individual must have full authority to bind the activity by his or her actions and commitments. The chief negotiator's job should be considered a full-time one during the negotiating process, and the incumbent needs adequate time to prepare for bargaining, carry out the actual negotiation, and review each session.

The management negotiating team should also include a representative from the civilian personnel office. A logical choice is the chief of the management-employee relations office. Typically, that person has coordinated managerial input relating to collective bargaining goals and is most familiar with the history of employee grievances and complaints at the activity and with its experience with unions.

One or more first-line supervisors, especially those from work areas having

s can also offer valuable in- the practical impact of a col- aining proposal.

on, because union proposals economic impact, the nego- n should include a budget nagement must know the mplications of a proposal in cide whether to accept it, re- ounter the offer.

g an attorney to the manage- is a controversial issue. union does not have an at- e bargaining table. If manage- the union may believe that sadvantage or that it should h attorneys from national s before agreeing to a pro- rth by the agency's counsel. e presence of an attorney g management may have a ect on give-and-take and on exchange of ideas during s.

an attorney can be more use- gement during preparations ng. He or she can analyze nd research the case law on

e case of a new contract, management should make judicious he Office of Personnel Management's Labor Agreement ation Retrieval System, which contains details concerning collective bargaining agreements previously negotiated.

on of contract clauses. A also draw up formal resolu- ose matters at impasse, that s on which the parties cannot ment.

one member of the team technical expert. Different will serve in that capacity, upon the issues up for For example, the agency's er would probably be the xpert during negotiation of article, while the chief of and placement might fill the ng discussion of the promo-

gaining process can help clarify or illuminate what the parties intended a clause to mean, long after the contract has been signed. Thus records can be useful in resolving disputes concerning the interpretation and application of contract clauses.

Once the management negotiating team has been assembled, the civilian personnel officer and the bargaining team should review the responses gathered from management during the goals-setting stage. Management's continued involvement in the process—in writing the contract proposal and in reviewing the union's proposal—will reinforce its commitment to the collective bargaining goals.

Writing the proposal. The next step is drawing up management's proposal. This process varies, depending on whether the team will be negotiating an original contract or renegotiating an existing one. Contracts are usually one, two, or three years in duration.

In the case of a new contract, management should make judicious use of the Office of Personnel Management's Labor Agreement Information Retrieval System, which contains details concerning federal collective bargaining agreements previously negotiated. Sample clauses available from the system can prove useful as models. Management should also consult any other collective bargaining contracts its agency may have signed in the past.

Renegotiation requires a thorough analysis of the existing contract. Clauses and policies that have proved troublesome or ambiguous should receive particular attention. The management team also needs to determine

should have specific examples and case histories at hand to support the change. And, as in earlier stages, input from managers can aid tremendously in defending a contract change proposed by management.

By the same token, when the union proposes a change to an existing contract, management should ask the union to justify the change with specifics. Also, it should compare each union proposal to related clauses in labor-management agreements at agency field activities and other federal agencies. By doing so, management can better assess the reasonableness of the proposal and, if necessary, formulate a basis to oppose it.

It is also a good idea to determine whether a contract proposal emanates from the local union or from a model contract supplied by the national union. If the latter is the case, management should ask the union to justify the proposal. Frequently, local union representatives are unable to satisfactorily defend a clause they did not engineer. Each union proposal should be distributed to managers throughout the agency for review and comment.

Ground rules. The final step before substantive bargaining begins is negotiating ground rules, which cover such things as where and when negotiations will take place, how often, procedures for signing agreed-to clauses, and procedures for invoking impasse resolution. In deciding on the number of hours per week to be spent at the bargaining table, management should set aside sufficient time during the work week to prepare for and, subsequently, review each session. Ensuring adequate withdrawal time is likewise important. Negotiating is a strenuous, tiring exercise, and negotiators need time away from the process to maintain the high degree of concentration and alertness the job demands.

Execution phase. Once the collective bargaining agreement has been signed, day-to-day administration allows management to monitor how well the contract is working. In short, this contract

Value Engineering should be improved as part of the Defense Department's approach to reducing acquisition cost

U.S. General Accounting Office, Washington, DC (GAO/AFMD-83-78, September 27, 1983). Request copies of GAO reports from: U.S. General Accounting Office, Document Handling and Information Services Facility, P.O. Box 6015, Gaithersburg, MD 20760.

Value engineering is a widely used technique for analyzing and redesigning a product so that its function can be achieved at lowest possible cost. Redesign generally involves the use of different materials, the application of new technology, or the elimination of components. Although an option during any phase of a project, value engineering is usually applied after product design has been established.

The Department of Defense established its value engineering program in 1963. Internally, DoD and the services perform their own value engineering studies and related work. Under the same program, contractors, motivated by the prospect of receiving a share of savings realized, also propose value engineering changes. Their proposals usually affect design and contract specifications deemed unessential and costly. As noted in earlier GAO reports, however, the contractor component of the program has not always yielded the benefits expected.

> *Of the military services, the Navy has done the least to improve the contractor component of value engineering. Its poor performance in this area reflects management indifference.*

In 1980, as part of an effort to strengthen the program, DoD took several steps to make contractors more aware of and responsive to value engineering objectives. First, it implemented a new contractual policy requiring inclusion of value engineering provisions in all subcontracts of $100,000 or more. It then established a formal savings goal to be achieved by the services through the adoption of value engineering change proposals. This goal, that total still fell more than $300 million short of the $448.7 million goal.

After conducting detailed discussions with selected defense contractors and assessing the currently used approaches to promoting contractor-initiated value engineering, GAO's audit team made four major recommendations for strengthening the value engineering program throughout DoD.

• The department should devise a better mechanism for ensuring continuous high-level visibility and support. The contractor component of the value engineering program is not systematically monitored at a sufficiently high management level. Although the DoD value engineering committee has become more active, it remains an advisory body, empowered to do little more than make recommendations. DoD should use the procurement management reporting system to disseminate value engineering information. Also, the Defense Systems Acquisition Review Council, which informs the secretary of defense on the status of weapon systems under development, should take more initiative in monitoring value engineering activity on major weapon systems.

> *Many field personnel who are responsible for value engineering oversight lack sufficient authority and perform such duties on a part-time basis.*

Responsibility for value engineering in DoD field organizations is often at too low a level as well. Many field personnel who are responsible for value engineering oversight lack sufficient authority and perform such duties on a part-time basis. A clear and visible endorsement of the value engineering program from the highest levels of the activity can go a long way toward alleviating problems associated with the organizational alignment of value engineering personnel.

• *DoD personnel need stronger incentives to encourage contractors to submit value engineering change proposals.* Procurement and program personnel tend to attach lower priority to value engineering responsibilities because the rewards for accomplishing other job duties are greater. The busy manager whose performance is being judged primarily on other factors, such as program schedule and system performance, may well regard the task of processing value engineer-

ge the submission of contractor proposals, but o review them fairly and expeditiously upon their t. Managers should review the relative importance ie engineering in the appraisal, award, and promo-rocess. Appropriate recognition of value engineer-hievements in these processes should be an in-part of top management support.

ne department should provide more direction, en-gement, and training to defense contractors and ntractors. For the contractor component of the engineering program to be effective, defense con-rs must understand the program and have able assurance that their concerns will receive ate consideration. However, contractors must earn to accept the fact that only about half of the engineering change proposals submitted will be ved. There are many legitimate reasons for disap-g a proposal, and DoD should provide the contrac-ull explanation of the rationale behind each rejec-

hermore, DoD can and should be more responsive tractor concerns about length of processing time, iveness of DoD personnel, and lack of value eering-related training. With additional manage-emphasis, DoD could monitor and reduce pro-processing time, devise ways to motivate its per-to be more receptive to proposals submitted, and e training opportunities to contractor personnel.

ne Navy should strengthen its value engineering m. Of the military services, the Navy has done the o improve the contractor component of value eering. Its poor performance in this area reflects ement indifference. The Navy can strengthen its

ne busy manager whose performance is being ed primarily on other factors, such as program dule and system performance, may well regard ask of processing value engineering change osals as an annoyance.

ach to value engineering by assigning appropriate ces, expanding internal training, and displaying a ne receptiveness to contractor proposals. GAO not accept the contention of some Navy officials her cost-reduction techniques are more deserving nagement attention.

the auditors expressed concern that the DoD value engineering program periodically suffers from varying degrees of management inattention. They added that in light of current congressional and public scrutiny of defense expenditures, the department should regard a vigorous, well-managed value engineering program as an integral part of the acquisition process.

Federal white-collar special rate program

U.S. General Accounting Office, Washington, DC (GAO/GGD-84-54, March 30, 1984). Request copies of GAO reports from: U.S. General Accounting Office, Document Handling and Information Services Facility, P.O. Box 6015, Gaithersburg, MD 20760.

Established by Congress in 1962, the special rate program gives the government greater flexibility in attracting and retaining employees in hard-to-fill occupations and in geographic areas where private-sector salaries are contributing to staffing problems. The law authorizes pay for those positions at a rate higher than that of the general schedule. The Office of Personnel Management administers the program, approving special pay rates when an agency provides sufficient evidence that it is having difficulty recruiting or retaining well-qualified individuals because of substantially higher private-sector pay for the same work. This report reviews selected aspects of the program and discusses alternatives for improving it.

Under the special rate program, an agency, upon receiving approval from OPM, may expand the number of pay-adjustment steps within a GS grade to as many as 19. Thus, while a non-special rate GS-13 can achieve a pay rate no higher than step 10, or about $47,000, a GS-13 under the extended special rate schedule could receive an annual salary of close to $58,000 at step 19. The program also allows an agency to hire individuals for OPM-recognized hard-to-fill slots at a beginning pay level as high as step 10 of the established entry-level grade for the position.

Although the program principally covers professional fields, particularly engineering and health care, it also

The fourfold increase over the last seven years in part reflects the failure of general schedule pay adjustments to maintain parity with private-sector pay. Also, those adjustments have been across-the-board rather than by level or type of skill. Adding to the problem is that the general schedule does not recognize geographical variations in pay.

Special salary rates cost the federal government $19.3 million in FY 1977. By FY 1984, that figure had risen to $115.7 million, an increase of 500 percent. However, due to OPM's recent pay adjustment decisions, the FY 1984 figure is expected to drop to $102 million.

Formerly, all special rate employees received at least the annual general schedule cost-of-living increases. In FY 1981, however, OPM changed its pay-adjustment policy for special rate employees and began granting (or withholding) annual pay adjustments based on an evaluation of agency staffing situations. As a result, OPM has been authorizing fewer and smaller pay adjustments for special rate positions. Agencies requested special rate increases of $35.3 million for FY 1982 and $30.2 million for FY 1983, amounts OPM reduced by $12 million and $29 million, respectively. In FY 1984, nearly 88 percent of special rate employees did not receive a pay adjustment.

OPM contends that its recent decisions have not hindered the government's ability to attract and retain employees in positions covered by the special rate program. Nevertheless, several large agencies believe the decisions are adversely affecting their operations, increasingly burdening them with high turnover, training and overtime costs, and work delays. OPM officials maintain that these agencies have not provided sufficient evidence to support these claims.

Although OPM and federal agencies, including DoD, may differ somewhat on the need for and proper extent of the special rate program, they agree that some kind of pay flexibility is needed to redress staffing problems in certain occupational fields. In its report, the GAO team identified four alternatives that might provide the flexibility needed and alleviate many of the problems now besetting the special rate program.

Expansion of special rate range and authority. Under current law, special rates can be used only to correct staffing problems caused by pay disparities between federal and private-sector pay. They cannot be used to redress other factors such as undesirable work conditions and location. ...

by factors other than pay disparity, perhaps by permitting agencies to place those hired in steps higher than now allowed.

Establishment of special occupational schedules. In 1976, the president's panel on federal compensation stated that the general schedule was not an effective tool for managing certain specialized occupations. The panel recommended that the executive branch be authorized to establish special pay schedules and personnel systems for those occupations in which the government has difficulty recruiting highly qualified individuals. Under this alternative, the executive branch could remove some occupations from the general schedule and establish separate pay systems. Although two 1979 pay reform bills incorporating such provisions were not enacted into law, the concept may warrant reconsideration.

Use of bonus incentive. The Navy has been developing a program under which an agency could offer one-time, lump-sum cash bonuses to hirees for hard-to-fill positions. However, an agency would be permitted to offer these bonuses only if it had already received authority to set the beginning salary for the position at the tenth step of the entry-level grade and could demonstrate that a recruitment and retention problem still existed. If adopted, the program would allow agencies to place newly hired employees in the special rate program and, in addition, offer them a bonus of up to $10,000. The recipient would incur a 12-month commitment to the government. The bonus concept could also be expanded to aid retention of employees in career fields continually experiencing pay lags.

Use of broader pay categories. In an ongoing demonstration project at the Naval Ocean Systems Center in San Diego, California, and the Naval Weapons Center in China Lake, California, the Navy is testing the feasibility of a pay system based on broad classification bands rather than on the grade-step structure of the general schedule. Four pay bands for scientists and engineers have replaced grades GS-5 through GS-15, and annual pay adjustments for individuals affected are based on a five-category performance rating system. The experimental project began in July 1980 and was originally scheduled to end in 1984. However, Congress recently extended its duration to the end of FY 1990 and removed limits on the number and type of employees who may participate.

The General Accounting Office ...

Value engineering efforts lauded

Four defense contractors have been cited for their value engineering achievements during FY 1983. Concerns recognized were Hamilton Technology Inc. (Army); Honeywell Undersea Systems Division (Navy); General Dynamics, Fort Worth Division (Air Force); and P. Burke Products Inc. (Defense Logistics Agency). John Mittino, the assistant deputy under secretary of defense for product support, presented the awards.

DoD instituted the product support awards program two years ago to spotlight the importance of value engineering as a means of reducing costs and increasing efficiency. In FY 1983, more than $130 million was saved through the adoption of 606 contractor-initiated proposals. *(OASD(PA) news release: April 18, 1984)*

Air Force gains in minority contracting

Early data tabulations indicate that the Air Force awarded contracts totaling nearly $595 million to minority-owned firms in FY 1983, exceeding its goal for the year by more than $40 million. The Air Force awarded $3.8 billion in prime contracts to small-business firms, an increase of close to $0.5 billion over FY 1982. Prime contract awards to women-owned businesses in FY 1983 totaled $118 million, 137 percent of the Air Force goal.

Although these figures still must undergo DoD-level review, it is unlikely that the final numbers will fluctuate by more than a few million dollars. *(Contracting and Manufacturing Newsletter: Vol. 21, No. 1, April 1984)*

Management gains elicit kudos

Deputy Secretary of Defense William H. Taft IV recently presented the Defense Superior Management Award to two individuals and three organizational elements.

Darold Johnson of the Naval Nuclear Propulsion Directorate was cited for his role in developing a standard logistics data system for naval nuclear propulsion systems. Also recognized was Colonel Donald J. Callahan (USA-Ret.), formerly with the U.S. Army Materiel Development and Readiness Command, who led the design effort on a multiservice communications system project; use of a commercial computer terminal on the project accelerated deployment by two years. Activities receiving the award were the Lightning B-52 quality circle in the maintenance directorate at the Oklahoma City Air Logistics Center for its contributions to the B-52 cruise missile program; the Air Force Systems Command's ballistic missile office for risk- and cost-reduction efforts associated with the PEACEKEEPER missile; and the material shortages central control staff at the Defense Electronics Supply Center for having assured the availability of critical electronic spare parts about to go out of commercial production.

These awards are presented periodically to recognize improvements in acquisition management. *(OASD(PA) news release: May 4, 1984)*

Naval shipyard earns productivity honors

The Norfolk Naval Shipyard has won a U.S. Senate productivity award in the nonmanufacturing category for Virginia-based businesses and government activities. The shipyard, singled out from among 6,000 companies and public-sector elements in the state, was specifically cited for its quality circles program and its incentive awards program. The purpose of the Senate-sponsored awards program is to recognize the contributions of organizations that improve productivity through implementation of cost-cutting and time-saving innovations. *(U.S. Senate news release: May 14, 1984; The Virginian-Pilot: May 15, 1984)*

Job satisfaction—all in the family

A study completed recently by two researchers at Maxwell AFB, Alabama, reaffirms the significance of the relationship between family-member attitudes and military job performance and satisfaction.

Using matched responses from 4,337 Air Force personnel and their spouses, Mickey R. Dansby and Janice M. Hightower constructed a multiple regression model to predict job-related satisfaction, perceived work group effectiveness, and desire to remain in the service. The sample consisted of enlisted personnel, officers, and civilian employees.

An individual's perception of family attitude toward his or her job was found to be the most significant contributor to job satisfaction and perceived work group effectiveness. The second most important factor was spousal identification with the military job. Contributing the most to an individual's intention to remain in the service

correlation between family attitudes and career, the researchers suggested that military officials should continue efforts to improve military family life. Specifically, they recommended that the services consider expanding the interface between job and family, designing work schedules so that the individual can have more time with his or her working spouse, minimizing extended travel assignments and permanent changes of station, and increasing family recreation services. *(Psychology in DoD Symposium Proceedings: April 1984)*

Schools get funds to upgrade research

The office of the under secretary of defense for research and engineering has selected 140 universities to receive funds to upgrade research equipment. These schools represent the second group of institutions selected under the DoD University Research Instrumentation Program, a five-year, $150 million initiative designed to enhance the capabilities of universities to perform defense-related research.

The approximately 1,900 proposals submitted were reviewed by the Army Research Office, the Office of Naval Research, and the Air Force Office of Scientific Research. The awards for FY 1984-85 represent an investment of $60 million and bring total funds granted so far to $90 million. The third solicitation will make available the remaining $60 million, to be allotted during FY 1986-87. A brochure announcing the solicitation will be issued in the summer of 1985. *(OASD(PA) news release: April 19, 1984)*

Drug abuse survey delayed

In the wake of an unexpected budget cut affecting studies and consulting contracts, DoD has postponed a worldwide drug and alcohol abuse survey, originally scheduled for fall 1984, until February, March, and April 1985. Sponsored by the office of the assistant secretary of defense (health affairs), it will be the third such survey since 1980 and is expected to cost approximately $325,000. *(Air Force Times: May 7, 1984)*

Contract awarded for new aircraft

The Air Force has awarded a $360 million contract to McDonnell Douglas Corporation for full-scale development of the F-15E, the Air Force's dual role fighter, which in addition to performing

The long-range F-15E will replace the aging F-4 and augment the F-111 force in the interdiction mission. It will have conformal fuel tanks (matching the fuselage of the F-15) for greater range and for weapons carriage of electro-optically and laser-guided bombs, Maverick missiles, and other air-to-ground armaments. In addition, the aircraft will have terrain avoidance capability.

The F-15E will be produced at McDonnell's facility in St. Louis. Flight testing is scheduled to begin in December 1986. The Air Force anticipates delivery of eight aircraft in FY 1986, 48 in FY 1987, and 60 annually thereafter until 392 have been delivered. *(USAF, Aeronautical Systems Division news release: May 1, 1984)*

Discrimination suit at Robins settled

In settlement of a suit citing alleged instances of race discrimination dating back to 1973, the Air Force has agreed to pay $3.75 million to 2,600 current and former employees of Robins AFB, Georgia. The action represents a legal compromise to close out a number of unresolved cases stemming from charges of race discrimination in personnel-related actions

tute an admission of guilt to the charges. The funds will be distributed to employees who worked at the base at any time from March 24, 1972, to the present. *(New York Times: June 19, 1984)*

OPM study reveals ADP grade inflation

Data released earlier this year by the Office of Personnel Management suggest that 28.5 percent of all computer-related positions in the federal government may be overgraded.

Indications of such overgrading were far less evident in DoD than in other agencies, according to the OPM study. Only about 18 percent of computer-related positions in DoD appeared overgraded, whereas nearly 45 percent of similar non-Defense positions did.

Reasons for the grade inflation included misinterpretation of criteria by position classifiers and inaccurate job descriptions. The figures could mean eventual downgrades and salary reductions.

A total of 18,600 individuals comprised the population sample, from which 500 positions in 87 activities were audited. A similar 1981 study found only 14 percent of all white-collar federal posi-

correlation between family attitudes and career, the researchers suggested that military officials should continue efforts to improve military family life. Specifically, they recommended that the services consider expanding the interface between job and family, designing work schedules so that the individual can have more time with his or her working spouse, minimizing extended travel assignments and permanent changes of station, and increasing family recreation services. *(Psychology in DoD Symposium Proceedings: April 1984)*

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